AIRPLANE STRUCTURES

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PREFACE

This book is written for the enlisted men of naval aviation. It is one of a series of books designed to give them the necessary information to perform their aviation duties.

A knowledge of airplane structures is of primary importance to Aviation Machinist Mates responsible for general maintenance work. But the subdivisions of Aviation Machinist Mates—that is, Aviation Hydraulics Mechanics, Aviation Instrument Mechanics, Aviation Carburetor Mechanics, Aviation Propeller Mechanics, and Aviation Flight Engineers—all of them need an understanding of the problems of airplane structures before pursuing their specialties to the broad subject of structures. Also they must be prepared to perform general maintenance work when the occasion demands it.

Starting with the basic principles of aerodynamics, this book discusses the purpose of various parts of the airplane, the materials and the construction. It follows with information on fabric and metal and plastic repairs. Then comes maintenance of flight controls, major assemblies and disassemblies, rigging, landing gear maintenance, and corrosion precautions. In conclusion, there is a section on the necessary inspections prior to flight.

As one of the NAVY TRAINING COURSES, this book represents the joint endeavor of the Naval Air Technical Training Command and the Training Courses Section of the Bureau of Naval Personnel.

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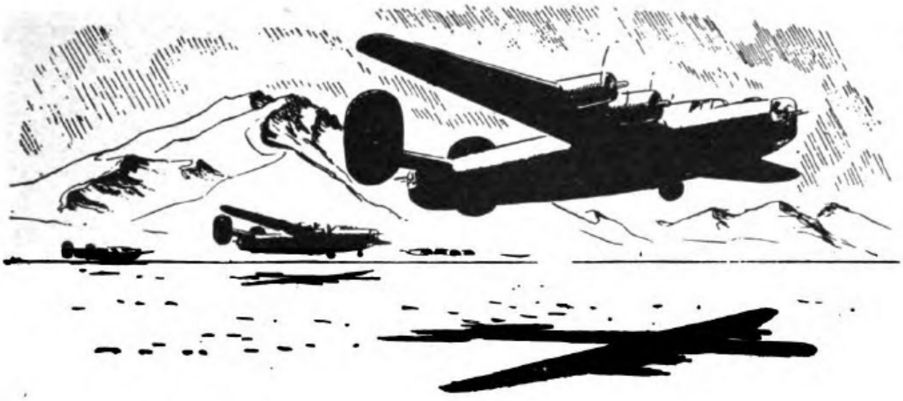


CHAPTER 1

AERODYNAMICS

HOW AN AIRPLANE FLIES

You can't pull a rabbit out of a hat unless it has been carefully put there first. Nor can you manufacture a trim and deadly Corsair fighter by mounting a powerful engine on a barn door. Building airplanes is no sleight-of-hand performance. It takes trained designers to do the job.

Today's airplane designers have just about beaten the birds at their own game. When you begin studying how they've done it, you're dealing in AERODYNAMICS. And that, as you undoubtedly know, is the study of what happens when an object moves through the air or the air moves over the object.

It has taken years of experiment to produce the structural parts of an airplane such as you see in figure 1. The shapes of wings and control surfaces, fuselages, landing gear, floats and hulls—none of these designs developed just overnight. It has taken time and patience to bring them to the near perfection of today. And it will take even more to develop the shapes of things to come—in the airplane structures of TOMORROW.

Designers long ago found out that if a surface (such as a wing) is shaped in a certain way it exerts a lifting force as it is moved through the air. Such a supporting surface is called an AIRFOIL. And the airfoil is the secret of an airplane's flight.

As you know, there's air all about you. You've probably observed the dust in the air on a hazy day. And, of course, you've noticed the moisture from your breath on a cold day. If you run fast into a breeze, you can sometimes hear the breeze whistle past your ears and you can even feel a slight pressure. But stick your head out of the cockpit of a speeding airplane—well, better not! You might lose it.

Speed makes the difference because it changes the velocity of the relative wind. An airplane must have speed to fly regardless of design. An airplane, flying on the level at 200 miles per hour has four times as much lift as it would have at 100 miles per hour. It's a different world up there in the blue.

To understand how an airplane flies, you must recognize first that there are four forces which

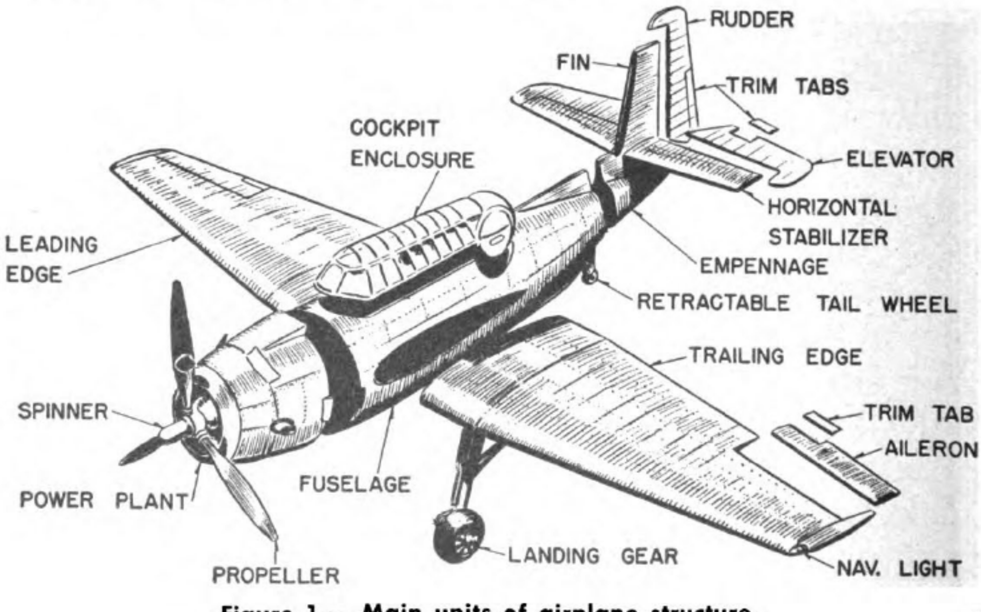


Figure 1.—Main units of airplane structure.

act on an airplane when it is in flight. GRAVITY is the force produced by the earth which tends to pull the airplane toward it. Opposed to gravity is LIFT, the upward force produced by the airfoils. DRAG is the force produced by the resistance of the air against the airplane itself. And THRUST, counteracting drag, is the forward force produced by the propeller.

The air has no lifting force or power unless there is relative motion. When it is moving, or an object is moving through it, however, it does exert a force. Airplanes utilize this force to stay in the air. Both airplanes and birds have the same sort of wing, shaped on a similar basic pattern. The bottom is comparatively flat, while the top is rounded. In the case of a bird, the wing's bottom side is slightly curved in. Now, if the wing is propelled forward some of the air goes over the top of the wing and some along the bottom. The air passing over the curved top must move faster than the air passing under the nearly straight bottom in order to get to the trailing edge of the wing in the same length of time. What actually happens is that the higher speed causes a lessening in the air pressure. With the pressure less on top of the wing than on the bottom, the wing is pushed up or lifted.

Take a look at figure 2. Here you have a cross section of an airplane wing or airfoil. The front edge is called the LEADING EDGE, and the rear, the TRAILING EDGE. A straight line between the leading edge and the trailing edge is known as the CHORD. The curve or departure from a straight line is known as CAMBER. If the camber produces a convex (curving outward) surface, the camber is positive. If the surface is concave (curving inward) it has negative camber.

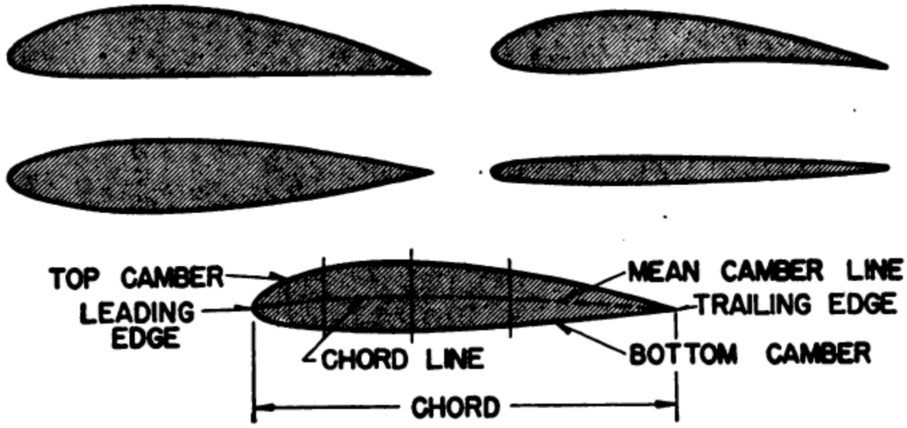


Figure 2.—Airfoil cross section.

The upper surface of an airfoil always has positive camber. And usually you'll find that the undersurface has a small positive camber, too, although it may have negative or zero (no curvature) camber.

What are the actual forces that operate on such an airfoil to lift it into the blue?

In ordinary flight, as you know, the leading edge of the wing is higher than the trailing edge. When the airstream hits the airfoil, it separates, part going above and part below. The part that goes below the airfoil, along the undersurface, creates undersurface lift. You can see that this is caused simply by the air striking against this undersurface. That's like aquaplaning on the water and is called IMPACT PRESSURE.

BERNOULLI STARTED IT

THE IMPACT OF AIR ON THE UNDERSURFACE PRODUCES ONLY ABOUT ONE-FOURTH OF THE TOTAL LIFT. THE OTHER THREE-FOURTHS IS THE RESULT OF THE DIFFERENCE IN PRESSURE BETWEEN THE UPPER AND LOWER SURFACES. How come? To answer that question you must understand a basic principle of the airfoil and all flying. It's called BERNOULLI'S LAW and is plenty important if you want to understand aerodynamics.

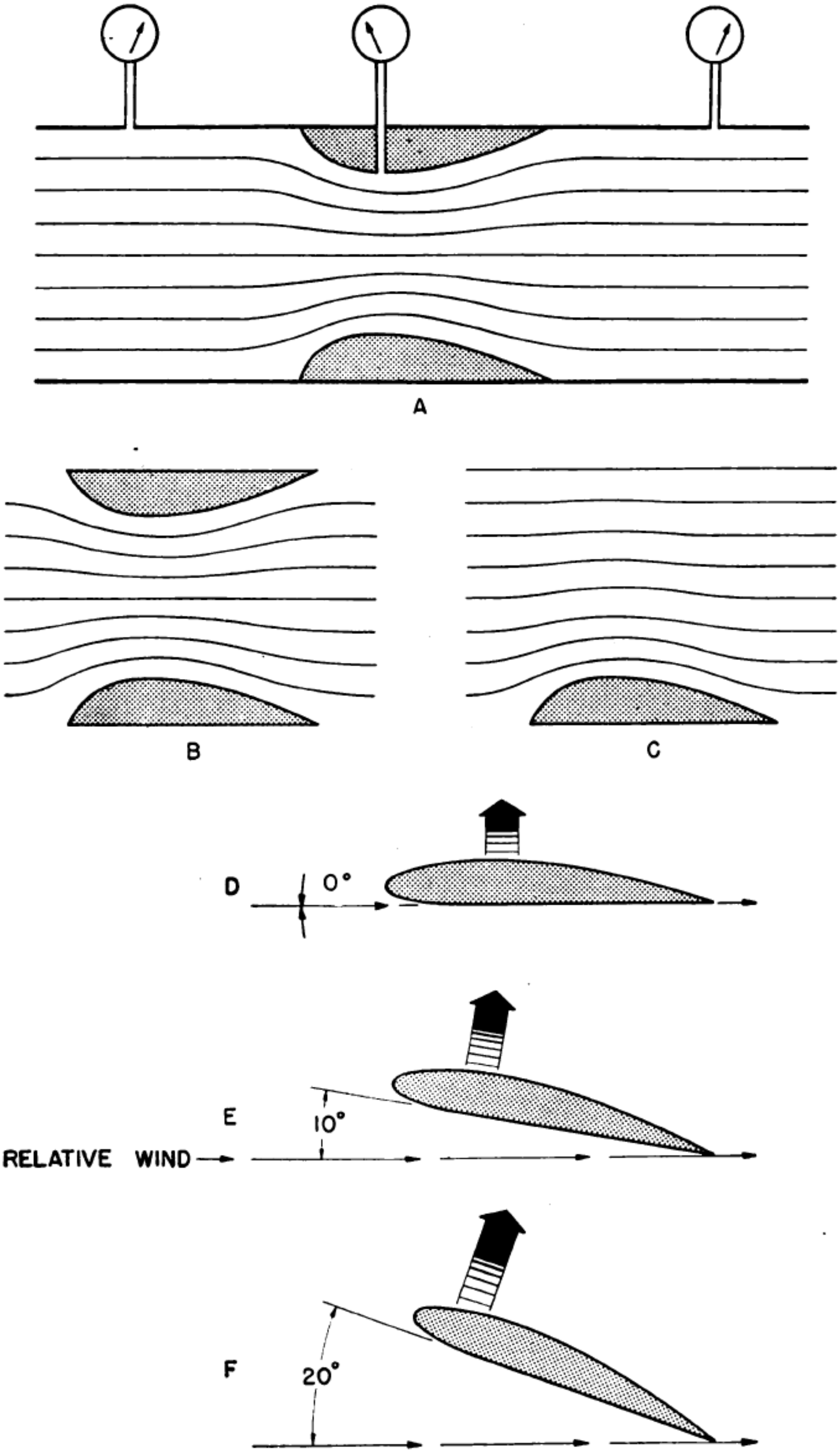


Figure 3.—Venturi principle.

If a fluid flowing through a tube reaches a constriction, or narrowing of the tube, the speed of the fluid through that constriction is increased, and its pressure is decreased. It is important to know that a confined fluid exerts equal pressure in ALL directions. If the fluid moves on into a tube of the same diameter as that of the original tube, the speed of the fluid will again become equal to the original speed.

Of course Bernoulli worked with liquids, but you'll find his law applies to air as well. In other words, the cambered (curved) surface of an airfoil (wing) affects the airflow just like a constriction in a tube affects fluid flow. This resemblance is in detail in figure 3.

In diagram *A* the air is passing through a constriction, according to Bernoulli's Law. In *B* the air is going through a wider, but still a restricted, opening. In *C* the air is going past a cambered surface, such as an airfoil, and the effect is similar to that of air going through a constriction.

With what you now know you can figure out how this works on an airplane wing. As the air flows over the upper surface, its speed or velocity increases and its pressure drops. An area of low pressure is formed. On the under surface of the wing there is an area of greater atmospheric pressure. This greater pressure tends to move the wing upward. And that is how lift is produced so that an airplane is kept in the air.

When an airplane takes off or climbs, the wings are inclined at a slight angle. The angle between the wing chord and the direction of the wind is called the ANGLE OF ATTACK. Figure 3, *D, E* and *F* also shows you three airfoils at different angles of attack.

What happens as this angle of attack is increased?

First, the impact pressure on the bottom of the wing exerts a slightly greater lifting effect. Second, there is a considerably greater reduction in the air pressure above the wing. Thus, as the angle of attack is increased, the lift is increased—up to a certain point.

When the angle of attack becomes too great, however, the air no longer flows smoothly over the top of the wing and the lift begins to decrease. The angle of attack below which lift increases, and above which lift decreases, is called BURBLE POINT or STALLING ANGLE.

SPEED vs. LIFT

Actually, if you were to measure the pressure above and below the wings, you'd find that the difference between that on the upper surface and that on the lower surface was not great at all. You probably will be surprised to learn that this difference may be as small as 0.16 pounds per square inch. But, if you multiply this difference by 144 (so as to find the pressure difference per square foot), you find that a lifting force of 23 pounds per square foot is produced. With 100 square feet of wing surface, this amounts to 2,300 pounds. Most airplanes have a much greater wing area than this and consequently can lift a much greater weight.

As you'd expect, the greatest lift is generally at the point of greatest camber. The amount of lift lessens from the high point of camber to the trailing edge of the airfoil. Consequently, if a designer wants this pressure drop to be large at a certain point, he must plan the curvature, or camber, so that it is large just before that point.

You've probably noticed that large airplanes, used to transport freight or bombs, have wings with a large amount of camber. This is because such airplanes must support a large weight. The large amount of camber produces not only greater lifting power but also an increase in drag. But, in the case of a freight transport, lifting power is more important than great speed.

No doubt, you've also observed that the wings of high speed airplanes are designed with a small amount of camber. That's because they must have high speed while weight carrying ability is of secondary importance. Logically enough, if the camber is small, the drag forces will be small and the airplane will be able to fly faster.

STREAMLINING

An early flyer once said that he could fly a barn door if he had an engine with enough power. On the basis of what you know about airfoils, you can reasonably doubt that statement. Besides the factor of lift, a barn door, with its flat front and irregular surfaces, would set up severe eddies behind it and, to some extent, around it. Of course, the barn door might produce some lift, but it would also have a high resistance to passage through the air.

How would you overcome these difficulties?

The answer is partial streamlining of airfoils so that the nose is smoothly rounded and the rear tapered off on a gentle curve. Usually the length of a streamlined body is three or four times the maximum diameter. If air is blown at the same speed against a flat surface and against a perfectly streamlined body, the resisting force (drag) produced by the flat plate is about 30 times that produced by a streamlined body. As the flat plate moves forward, you see, there is a

large area of decreased pressure behind it. This creates a drag force which slows forward motion.

If a cylinder and a streamlined body are compared under similar conditions, the resisting force produced by the cylinder is about 15 times greater than the force produced by the streamlined body. As the cylinder moves forward through the air, an area of decreased pressure is also created behind it. To be sure, it is smaller than in the case of the flat plate. A streamlined object, as you see in figure 4, fills the space which would otherwise contain an area of decreased pressure. This reduces drag to a minimum. Streamlining, then, is shaping an object to conform to the airstream moving around it and, by this means, to eliminate as much drag as possible.

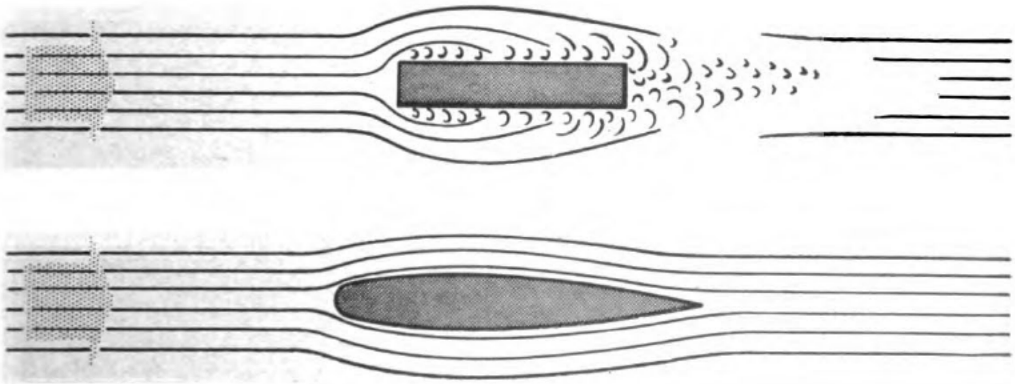


Figure 4.—Streamlining.

There's one hitch about a PERFECTLY streamlined body. It will NOT give any lifting force because it does not create the differences in pressure above and below, as does an airfoil. In the case of an airplane, the airfoil must be designed to give lifting force in a certain direction. So an airfoil is actually a compromise which is calculated to produce a great lifting force with as near perfect streamlining as possible. The degree of streamlining varies according to the use to which an

airplane is to be put. For instance, the modern fighter in which lift is subordinate to speed, is so well streamlined that it offers about the same resistance as a 22 inch square flat plate.

DRAG

You're already acquainted with the term DRAG. Designers are continually experimenting with new airfoil shapes in order to develop more efficient and better airfoils, as well as to find other ways of reducing this drag. Yet it continues to be a problem.

There are three types of drag—PROFILE, INDUCED and PARASITIC.

PROFILE DRAG is the kind brought about by the shape of the object moving through the air and by the friction of air on the surface of the object. You seldom think of air as being sticky. Nevertheless, it tends to stick to the surface of an airfoil moving through it. This causes a drag known as skin friction. Airplane surfaces are made as smooth as possible to reduce this skin friction. Rivet heads on all-metal airplanes are made flush with the surface. It was demonstrated on one fighter that by making the rivet heads flush with the surface instead of allowing them to project, the speed of the airplane was increased 35 miles per hour.

The pressure on the under-surface of an airfoil is greater than the pressure on the upper surface. Since air, like water, seeks its own level, some of the air on the under-surface tends to move outward toward the wingtips and upward around the wingtips as shown in figure 5. These two air currents meet at the outer rear portion of the airfoil and set up a vortex (turbulent, eddying air). The air on the under-surface has a tendency to move in toward the fuselage and off the inner

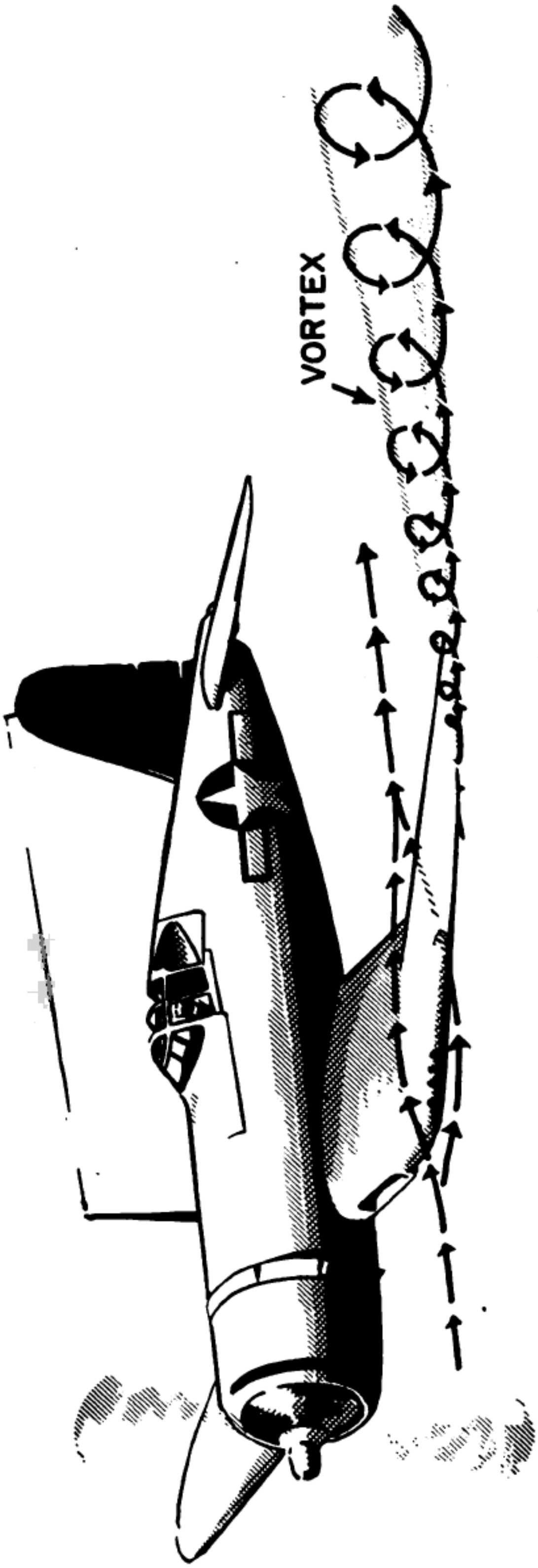


Figure 5.—Air vortex at wingtips.

trailing edge. This air current forms a similar vortex at the inner portion of the trailing edge, near the fuselage. These vortices constitute INDUCED DRAG.

PARASITIC DRAG is the result of resistance by parts other than lifting surfaces. As you'd expect the fuselage produces the greater portion of this type of drag. Landing gears, of course, formerly contributed greatly to parasitic drag, but the retractable landing gears have brought a substantial reduction in this type of drag.

CENTER OF GRAVITY

You'll have to be careful not to shift any part or move any weight on airplanes you're working on which might put the CENTER OF GRAVITY back too far. Otherwise, the pilot is going to be in for trouble.

The point at which the mass of a body is centered and at which perfect balance is attained is called the CENTER OF GRAVITY. It's a mighty important factor in its bearing on the stability of an airplane. Early designers were not aware that it was necessary to keep the center of gravity in front of the center of lift to produce a stable airplane. With the center of gravity in front of the center of lift, the airplane will nose down if the engine fails to function or the airplane stalls. With its nose down, the airplane will attain enough speed to produce a lifting force adequate to support itself.

CHAPTER 2

CONTROL OF THE AIRPLANE

THREE AXES

An airplane has three axes but they don't have anything to do with the Axis Powers we're fighting. The axes of an airplane are the lines about which it rotates as it turns and banks, dives and climbs.

You can visualize these axes by thinking of them as lines passing through the airplane's center of gravity where each will then intersect the other two. Each axis is also perpendicular to the other two. Take a look at figure 6 and get the position of these axes clearly in mind. The axis that extends lengthwise (from prop to tail) is called the LONGITUDINAL AXIS. The axis crosswise is called the LATERAL AXIS. And the axis that passes vertically through the center of gravity is called the VERTICAL AXIS.

Any change in the attitude of the airplane, with respect to the ground or any other fixed object, involves rotation about one or more of these axes. Remember, too, that an airplane can rotate about all three axes at the same time.

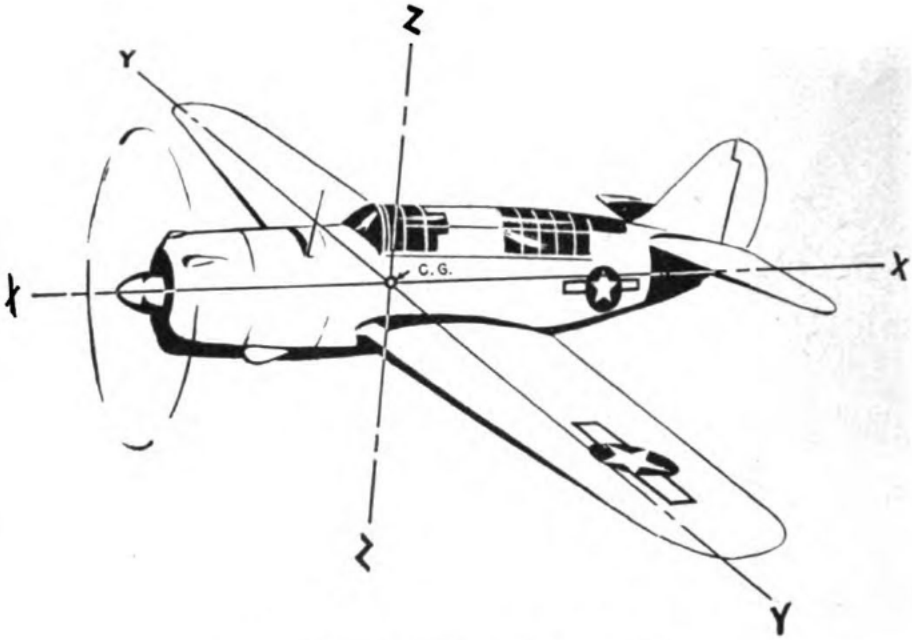


Figure 6.—Three axes of airplane.

You ought to be familiar with three other terms used in connection with rotation about the axes. First, rotation about the longitudinal axis is called ROLL, about the lateral axis, PITCH, and about the vertical axis, YAW. Figure 6 will help you to get these three terms, and what they mean, in mind.

HORIZONTAL TAIL SURFACES

Suppose you find that your airplane tends to dive while in normal flight. You'll pull back on the control stick to bring the nose up. But if this tendency continues, you'll have to exert a continuous backward pressure on the stick. This would prove extremely tiring if you had to keep it up for any length of time. The horizontal surfaces, however, are designed to offset this downward force.

In actual experience though, you'll find that the combination of thrust and drag may give one airplane a tendency to dive, and another a tend-

ency to climb. But, IN EITHER CASE, the horizontal surfaces, particularly the stabilizer, are designed to counteract such tendencies and keep the airplane in level flight.

In controlling the rotation of the airplane about the lateral axis (wing tip to wing tip) you move the elevators. If you want to bring the nose down, you exert forward pressure on the stick. This lowers the elevators. Both the camber (curve) and the angle of attack (the angle between airfoil and airstream) of the horizontal tail surfaces are increased. What happens? An upward lift is produced on the tail surfaces. The tail goes up and the nose down.

Now suppose you want to climb or pull the nose up. You pull the stick backward, raising the elevators. Now what happens? A negative lift or a downward force is exerted on the horizontal tail surfaces, lowering the tail and raising the nose. Take a look at figure 7 to see how the elevator control system works.

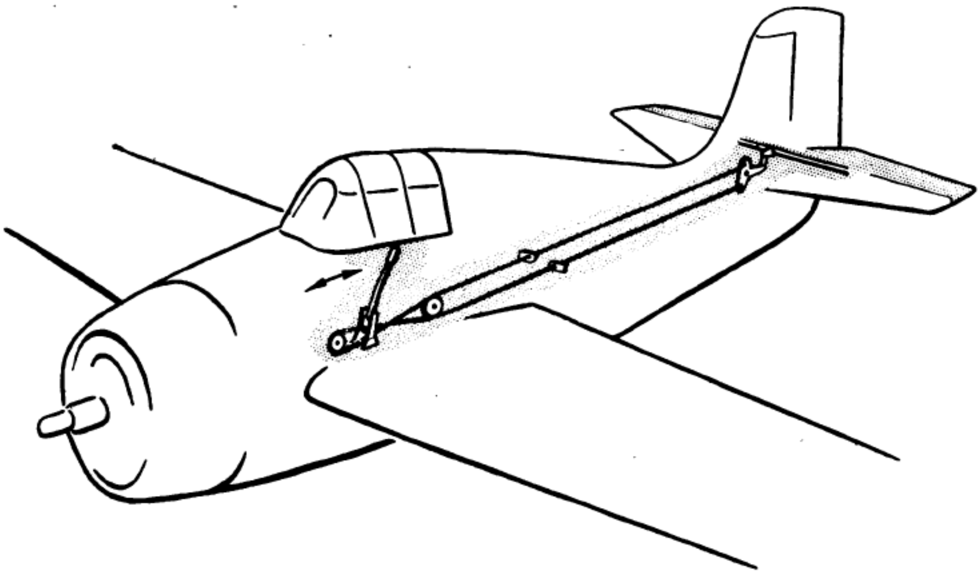


Figure 7.—Elevator control system.

If you examine the horizontal surfaces on the tail of an airplane, you'll see that the top camber and bottom curve are identical. In other words, the curve from the leading edge to the trailing edge is the same on both sides. Such airfoils are called DOUBLE-CAMBERED. They're designed that way because they may be called upon to give either upward or downward forces, so as to climb or dive.

You'll find that stabilizers and elevators are constructed in various shapes. Figure 8 shows three typical types. You can see in (*B*) and (*C*) of the diagram that part of the elevator extends

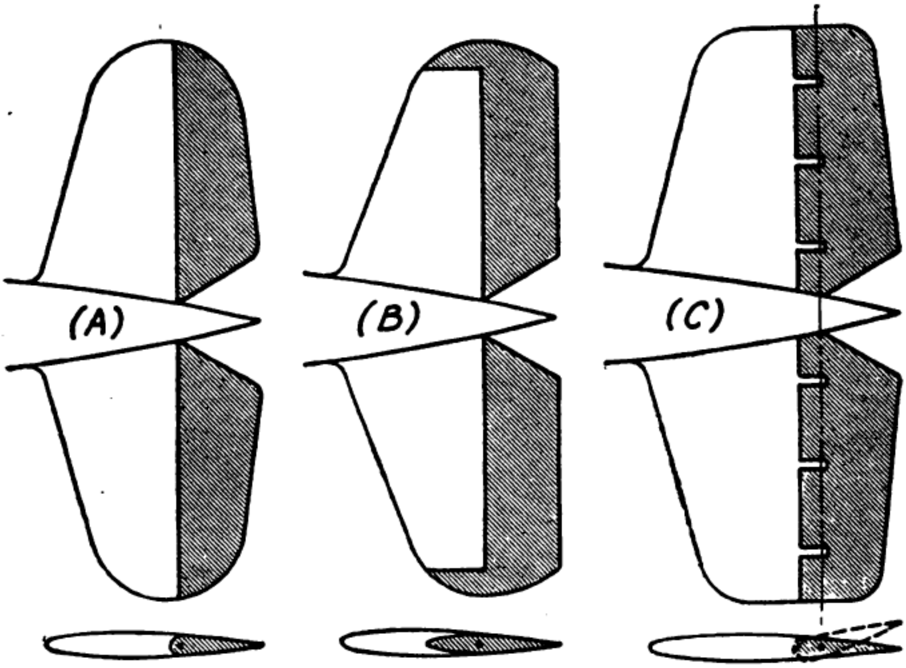


Figure 8.—Elevators and stabilizers.

beyond the hinge line. You move the stick backward, the portion of the elevator in front of the hinge will move downward while the main part moves up. The air acting on the portion forward of the hinge tends to move the main surface in the same direction that you are attempting to move it. The type shown in (*A*) is the ordinary type with no part of the elevator forward of the hinge line.

The type shown in (*B*) is known as the overhang balance, and the type shown in (*C*) is called a Handley-Page balance.

VERTICAL TAIL SURFACES

The fin and rudder of an airplane control its movement about the vertical axis—that is, either to the right or left. In other words, the combination of the fin and the rudder produce, or correct for, YAW.

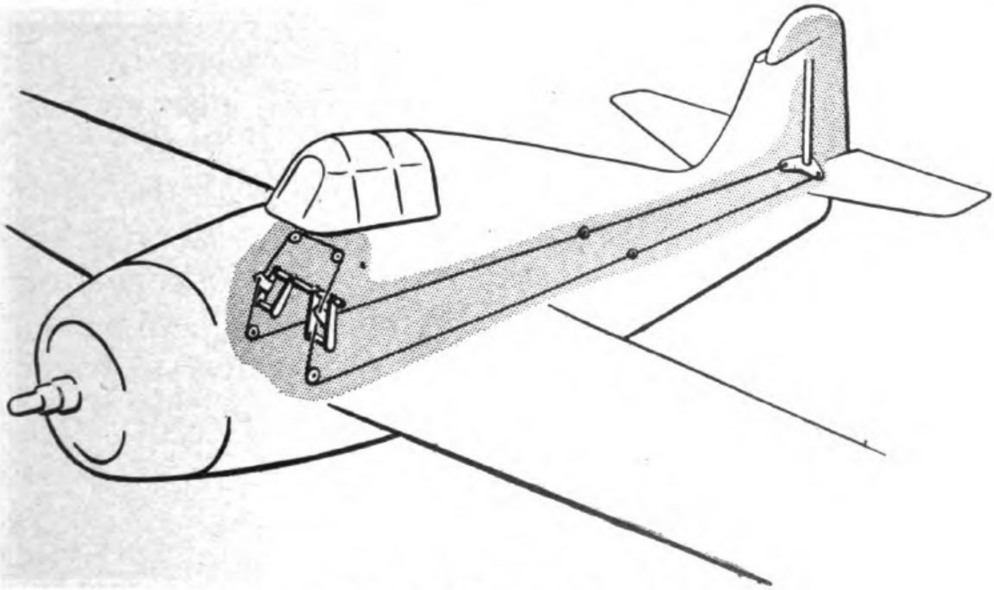


Figure 9.—Rudder and tail wheel control system.

The vertical surfaces work like the horizontal surfaces, except the movement produced on the airplane is sideways instead of up or down. By increasing the angle of attack and the camber at the same time, the vertical surfaces exert a sideways lifting force that swings the tail and consequently the nose. Figure 9 shows you how the rudder and the tail wheel (operating on the same principle) work.

You operate the rudder by means of pedals in the cockpit. When you move the rudder of the airplane to the right, the nose also moves to the

right. And you move the rudder to the left to turn the nose to the left. The reason is because moving the rudder to the RIGHT causes a force to act toward the left on the tail.

AILERONS

When one aileron moves down, the camber of that wing is increased. This increases the lift on that side and the wing goes up. At the same time, the other aileron is moving up. That decreases the camber on that side and causes the wing to go down. This action produces rolling or banking. The ailerons are controlled by movement of the stick to the right or left, as you can see in figure 10.

In a turn, the aileron on the inside of the turn is raised and the lift on that wing is decreased. This slightly decreases the drag. The aileron on the outside of the turn, being down, increases the drag. The additional drag is then a force that acts opposite to the direction of the turn.

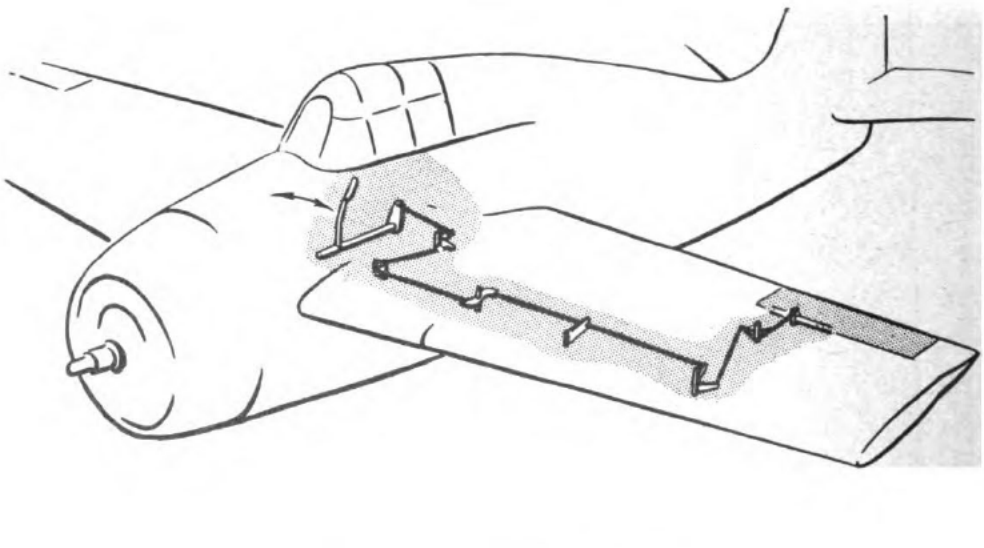


Figure 10.—Aileron control system.

This force must be offset by use of the rudder. Right now is as good a time as any to get in mind, though, that THE ONLY PURPOSE OF THE RUDDER IN NORMAL FLIGHT is to offset the drag produced by the lowered aileron. If the aileron didn't increase the drag on the outside wing, it would be possible to make perfect turns without using the rudder at all. So remember, THE RUDDER CANNOT ACCOMPLISH TURNING BY ITSELF.

TRIM TABS

On large airplanes, the controls are equipped with small movable sections known as trim tabs. If you look at figure 11, you'll see how a tab works. Suppose that the tab is on the elevator.

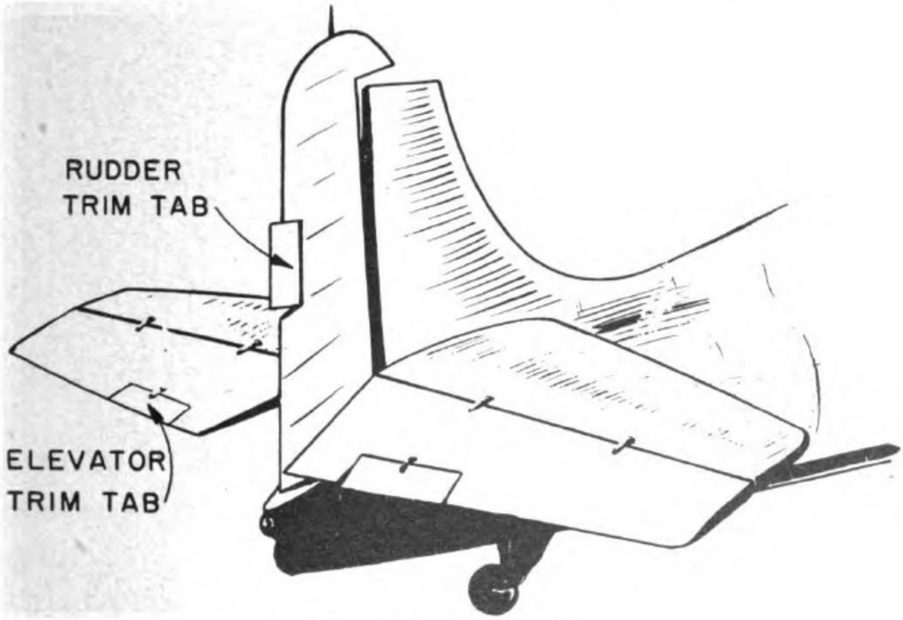


Figure 11.—Trim tabs.

If the tab is depressed, it increases the camber of the elevator. This increases the lift on the elevator only, causing it to rise. Actually this effect corresponds to pulling back on the control column, for when the main elevator rises the force on the tail is downward.

In small airplanes, tabs often consist merely of a piece of sheet metal attached to the trailing edge of the surface. If the airplane shows a tendency to be nose-heavy or tail-heavy, the tab on the elevator is simply bent in the proper direction. Likewise, if the airplane tends to YAW, the tab on the rudder is bent in the proper direction. So think twice before you do anything which might disturb the bend of such a tab.

CHAPTER 3

MATERIALS

WHAT AIRPLANES ARE MADE OF

In the late twenties and early thirties, many flyers barnstormed all over the country in dilapidated old crates. You may remember some of them—five dollars for a five minute ride and better have your insurance paid up!

Some of those airplanes were tied together with baled-hay wire and were patched up by the village carpenter in whatever town they had trouble. They flew with little horsepower and lots of prayers.

Those were the days of wooden airplane construction and steel nerves. Wood was considered cheaper, lighter, and more durable than metal. The wings, spars, and ribs, the interplane struts, the longérons and fuselage struts, and the tail surface spars and ribs were all wood. Even the propeller and the engine mount were of wood.

And, of course, the fuselage and surfaces were covered with fabric.

The last 10 years, however, have brought tremendous progress in airplane construction. You may run into some training airplanes with certain parts made of wood. But most of the time you're going to be working on airplanes built of various metals.

Some woods are quite strong considering their weight. Probably spruce is the one most commonly used. It's light in weight, straight-grained and moderately strong. Other woods used are ash, birch, cedar, Douglas fir, mahogany, gum, maple, pine and oak.

PLYWOOD is also used. It is made of thin layers of wood veneer glued together with the grain of one layer at right angles to the one next to it. Plywood is used for box spar facings, wing rib webs, as coverings for leading edges, and for interior fittings.

There's another type of wood, quite similar to plywood. It's called LAMINATED WOOD and consists of two or more pieces of wood glued together with their grains running parallel, or nearly so. Lamination reduces warping, increases strength and makes it easier to form special shapes. Propellers, wing spars, and wing tips are sometimes constructed of laminated wood.

ALUMINUM

Modern airplanes are built mostly of ALUMINUM ALLOYS. Aluminum without alloying material is rather weak. That's why it was not used to any extent for airplane parts until 15 or 20 years ago when strong aluminum alloys first became available.

Aluminum itself is a white, shiny metal, light in weight and corrosion resistant. Various percentages of other metals, generally copper, manganese, and magnesium, are combined with aluminum to form the alloys used in aircraft construction. Most of these alloys are about 95 percent aluminum, so the weight is still small relatively. But—and here's the important factor—the strength of these alloys is more than DOUBLE that of aluminum.

For convenience, the various aluminum alloys are given symbols and you'll speak of them that way. Alloy 17S is used for stressed-skin covering, protruding structural parts, and rivets. Alloy 24S is used for heat-treated parts, airfoil covering, and fittings. It is stronger than 17S. Alloy 25S is used for propeller blades, and alloy 52S for fuel lines, hydraulic lines, fuel tanks, and wing tips.

The strong aluminum alloys must be heat-treated to acquire their strength. And here's a point to remember—the improper application of heat to these alloys destroys certain strength properties and also makes them much more susceptible to corrosion from salt water. So take care when you're applying heat to a part.

To LESSEN the danger of corrosion, aluminum alloy sheet is sometimes made with a thin layer of pure aluminum on the outside. That's called "Alclad." It's manufactured by sandwiching the alloy ingots (from which the sheet is rolled) between thin sheets of pure aluminum, and rolling the "sandwich" out into a thin ribbon-like strip. Alloy 24S is often "Alclad" to improve its resistance to corrosion.

STEEL

When you want great strength, however, you still turn to steel. You'll find that landing-gear

axles and engine mounts are almost invariably made of steel in all types of airplanes. But, as in the case of aluminum, certain alloys of steel have been found to offer distinct advantages.

Probably the most popular of alloy steels for airplane use in that made by MIXING CHROMIUM AND MOLYBDENUM with the steel. Such steel is referred to as chrome-molybdenum steel, but you'll probably hear it spoken of more often as "chrome-moly." Molybdenum steels are tough and wear resistant, and are hardened by heat treatment. They are especially adaptable for welding and, for this reason, are used principally for welded structural parts and assemblies, such as fuselages, engine mounts, and gear structures.

Nickel, vanadium, manganese and numerous other elements are also used as alloying metals with steel. Ordinary low-carbon steel has an ultimate strength of around 50,000 to 60,000 psi. Alloy steel, properly heat-treated, can develop from four to five times as much strength.

Heat treatment, in fact, is the secret of the strength of alloy steel. While these steels are stronger, even when not heat-treated, than mild steels, heat-treatment imparts to them their maximum strength properties.

The process consists of heating the steel to a temperature ranging from 1,500° to 1,800° F., quenching it (dipping it in oil or water), and then reheating it to a much lower temperature, perhaps 1,100° or 1,200° F., and allowing it to cool slowly. If steel is merely heated, as by welding, and is not quenched and reheated, it loses much of its strength. So mark this one down—GREAT CARE SHOULD BE TAKEN IN APPLYING HEAT TO ALLOY-STEEL PARTS. Otherwise, they may be weakened and might fail in flight.

CADMIUM PLATING

Navy airplanes are constantly being exposed to corrosion from salt water. You can see that this presents real problems in war time when carriers may be at sea for months and when South Pacific hangars are often nothing more than open-air clearings in jungles.

How are the parts protected?

The answer is CADMIUM PLATING for many steel, bronze, and brass parts. It is the cheapest and most efficient method. Moreover, cadmium-plated parts are especially favored in seaplanes where the corrosion hazard is great.

Cadmium is a metal, harder than tin, but nevertheless malleable. That means it can be hammered or molded. The actual plating process is done by electricity, but you don't need to go into that here. Parts which are cadmium plated include screws, nuts, bolts, steel springs, and brass bushings.

Other parts which are not plated may be covered with ZINC CHROMATE, one of the newest substances used to prevent corrosion. Zinc chromate is applied like a paint by brush or by spraying.

PLASTICS

You won't be flying off to Tokyo in one tomorrow. But some day, not so far distant, there may be lots of "cooked" airplanes crowding the airways. Right now, and on Navy airplanes, you'll find many parts that are cooked—that is, shaped or molded under heat and pressure. Such materials are known as PLASTICS.

Even today, entire airplanes are being built of thin layers of wood with plastic in between. These are usually referred to as "plastic-airplanes,"

although, since they use a great deal of wood, they are not truly plastic in construction. This form of construction offers great possibilities, since entire fuselages and wing sections can be molded on forms at low expense. Plastic airplanes are lighter than those of metal construction, and it is probable that this type of construction will be used more and more as additional research improves it.

Bakelite control knobs, PLEXIGLAS gun turrets and PLASTACELE windshields have been used in the manufacture of airplanes for some time. You've run into lots of plastic gadgets, too, in your every day life—knobs and handles, radio cabinets, and ash trays. There were more than 85 plastic parts used in an old prewar automobile.

In general, the various types of plastics have certain characteristics in common. They have smooth surfaces and are not subject to rust, chipping, or denting. They're light and durable as well as tough.

Plastic molding materials may be classed in two groups—THERMOSETTING and THERMOPLASTIC. Thermosetting compounds are formed to the desired shape under heat and pressure. The resulting product is permanently hard. IT CANNOT BE RESOFTENED by heat or remolded. That's the important point to remember. Thermoplastic molding materials, on the other hand, do not become hard with the application of pressure and heat. They remain soft in the mold until they are hardened by cooling. Moreover, THEY MAY BE SOFTENED repeatedly by further heating.

Among the thermoplastics which you'll find on airplanes are plexiglas and plastacele. Probably PLEXIGLAS is the most important plastic now being used in airplanes. That's what the windows for the bombardiers and all the important gun "blis-

ters" are made of. Plexiglas can be MOLDED to any shape, is MORE TRANSPARENT than plate glass, BURNS VERY SLOWLY when subjected to an open flame, but is NOT READILY IGNITED.

PLASTACELE is used chiefly for windshields and cockpit enclosures on small airplanes. It will ignite in an open flame, but burns slowly.

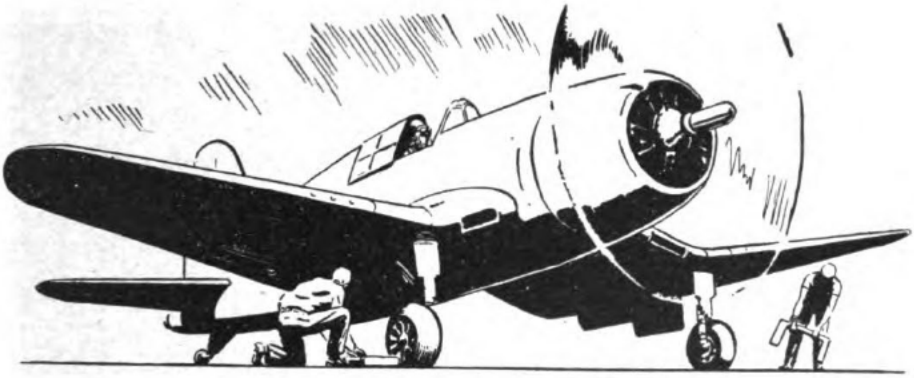
BAKELITE is in the thermosetting group. Oftentimes sheets of paper or fabric are impregnated (soaked) with this plastic and placed in layers to obtain the desired thickness. The result is a smooth, shiny material which is also strong and tough. It doesn't conduct electricity, and so has been found especially useful in the manufacture of electric equipment such as control panels and magneto distributors. You can also obtain bakelite stock in the form of sheets, tubes, or rods of various dimensions.

FABRICS

Some people have the idea that DOPED FABRICS are now obsolete, but they're wrong. Of course, fabric is no longer used throughout airplanes as a covering skin, but an altogether suitable substitute for covering control surfaces, trailing edges and similar parts has not yet been found.

You'll still find that a cotton fabric is used extensively for the covering of surfaces of small, low-speed, training-type airplanes and for covering control surfaces on high-speed airplanes. This fabric is produced in various widths, the weights of which range from 4.0 to 4.5 ounces per square yard. It has a strength of 80 pounds per inch of width.

After the fabric is attached to the airplane structure, it is treated with cellulose acetatebutyrate dope. This tends to shrink the fabric and produces a smooth taut surface.



CHAPTER 4

STRENGTH FACTORS

TOUGH ENOUGH TO TAKE IT

How strong should an airplane be?

"The stronger the better," you answer. And YOU'RE RIGHT. But there are other considerations. Of course, it would be swell to have an airplane that could pancake onto a carrier deck from 40 feet in the air without breaking the landing gear. It would be swell if wings were strong enough so that they wouldn't break off if you landed in a tree. And such an airplane COULD be built!

But—and here's the hitch—such an airplane would not fly, because it would be too heavy. Consequently, in matters of strength as well as other things, the designer must compromise. The strength of the airplane, just as the performance, is determined to a large extent by what the airplane is to be used for. A dive bomber, which must dive at high speed and pull out abruptly, must be stronger than a transport, which is never expected to perform any such maneuvers.

In studying strength, you must learn the effect of load upon different types of members. MEM-

BERS are parts (of the airplane) which are designed to carry load.

If you take a piece of rope in your hands and attempt to break it by pulling, you APPLY A LOAD to the rope and you subject the fibers of the rope to STRESS. In other words, as you exert an external force, internal resisting forces are developed in the body. These resisting forces tend to balance the external applied force. The internal force, acting between adjacent particles of the body, is called stress. You measure stress in terms of force per unit area—normally, pounds applied to each square inch of cross-sectional area.

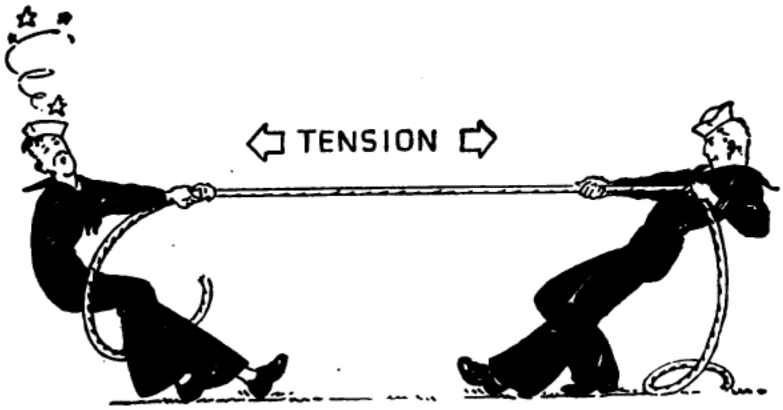
Suppose the rope you were pulling had a cross sectional area of ½ square inch and that you were exerting a force of 50 pounds. What would the stress on the rope be? That doesn't take much figuring. If it's 50 pounds for ½ square inch, then it would be twice as much—or 100 pounds per square inch (100 psi).

Depending on the arrangement and direction of the external forces, the stresses produced in a body may be—TENSION, COMPRESSION, SHEAR, BENDING, TORSION, or a COMBINATION of two or more. Each part of an airplane structure may be subjected to one or more of these stresses.

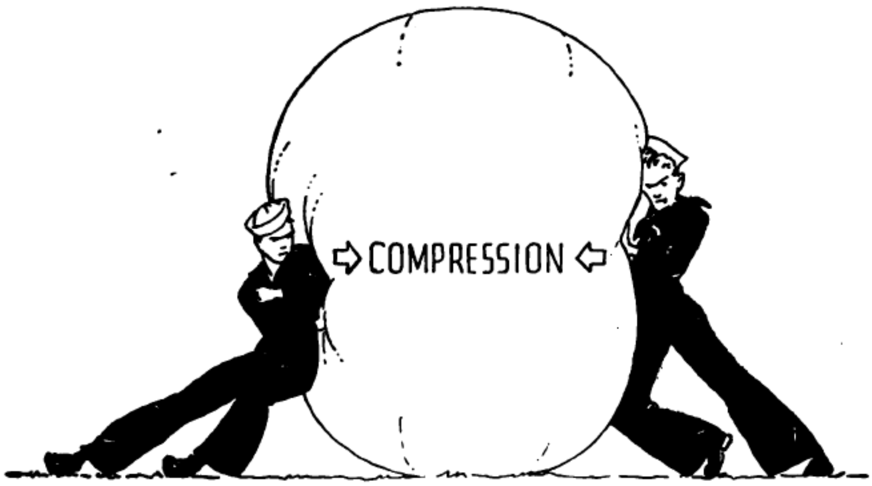
When external forces act upon the ends of a bar, rope, or strut in a direction away from the ends, the resulting stress is called TENSION (fig. 12). That's what you were creating in the rope.

The opposite type of force tends to shorten or push together a rigid member. The resulting stress is called COMPRESSION as shown in figure 12. When you are sitting in an ordinary chair, the four legs are subject to such a stress.

If you've ever worked out in a gym, you've probably chinned yourself on a horizontal bar.



(A)



COMPRESSION

(B)

Figure 12.—Tension and compression.

Your weight suspended from this bar tends to bend the bar. This illustrates another kind of stress. It's known as BENDING. Look at figure 13. Whenever bending stress occurs, there is a pushing together on the concave side and stretching on the convex side of the member, as you see in figure 13.

When you turn the steering wheel of your car, there is a twisting force applied to the shaft

Figure 13.—Bending.

which runs down to the steering mechanism, and the twisting stress, to which the shaft is subjected, is known as TORSION. This is illustrated in figure 14.

Suppose you fasten two straps of metal together with a bolt and then pull on the ends of the straps parallel to their length. There is a tendency for one strap to slide on the other and also a tendency for the bolt to break off between the two straps. The bolt is being subjected to a stress known as SHEAR. It's really like placing a thread between the blades of a pair of scissors. In fact, that's how shears got their name. Take a look again at figure 14 which shows a type of shear.

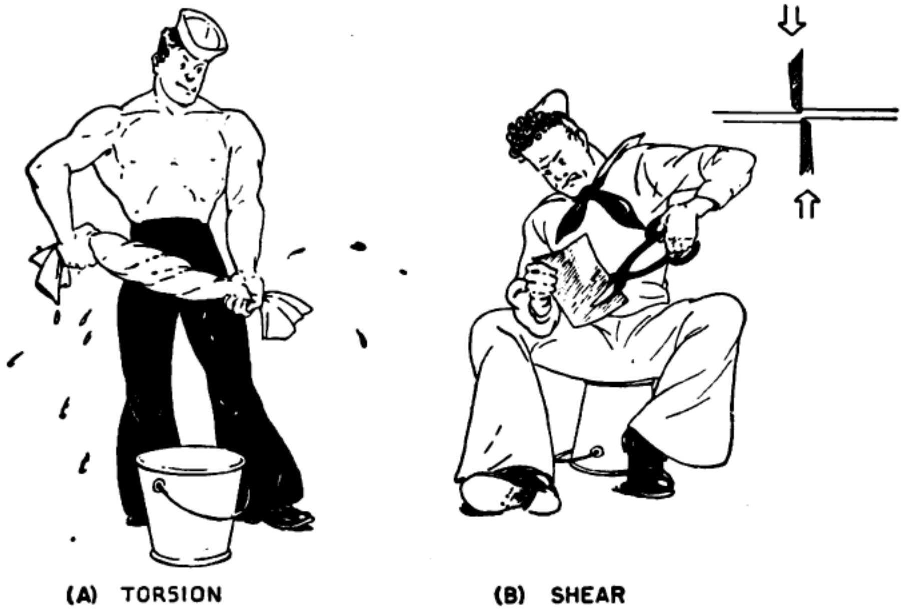


Figure 14.—Torsion and shear.

There you have the five principal types of stress. But of course, a single member of an airplane is often subjected to a combination of these stresses. You can see that the same member couldn't be subjected to both tension and compression at the same time, but it might be required to withstand compression and bending at the same time, or even compression, bending, torsion, and shear. Likewise, it might be subjected to tension and bending, or to bending and torsion. You can figure out for yourself other combinations which may be found in an airplane's structure.

All the members in an airplane are subjected to one or more of these types of stress. Some members may be subjected alternately to compression and tension. For instance, the supports of a landing gear may carry compression as the airplane taxies across an airfield. After the airplane takes off, the same members may carry tension because of the weight of the landing gear. However, the tension, in this case, would be relatively small compared with the compression. Of

course, some members can carry only one type of stress. Wire and cables are examples. They can carry only tension.

The wing spars are subjected to bending while the airplane is in flight. In the wing of an externally braced high-wing monoplane, the wing spars are carrying both bending and compression while the airplane is in flight.

An example of torsion is found in the torque tubes by which the controls are usually operated. Another example is in the crankshaft of the engine.

There are countless examples of shear throughout the structure of the airplane. Rivets are INTENDED to carry nothing but shear. Bolts, as a rule, carry only shear, although occasionally they may be subjected to tension.

END LOADS BEST

For sturdy airplane design, it is usually desirable for members to carry END LOADS rather than SIDE LOADS—in other words, to be subjected to tension or compression rather than to bending.

Do you see why end loads are more desirable?

You can easily prove to yourself that a member is stronger in compression or tension than in bending. Take a stick of wood about ½ inch in diameter and try to break it, either by pushing directly on the ends or by pulling on opposite ends. It's no go—unless the stick is very long, and you do not push in a straight line. But put this stick across your knee, and push down on the ends so that you exert a bending force on it. You can easily break it.

In order to arrange members so that they will carry mostly end loads, rather than side loads, designers have combined the members into what is known as a truss. You can see an example of

what is called a PRATT TRUSS at the top of figure 15. In this truss, the longitudinal and vertical members are tubes or solid rods. The diagonal members are wires. Ordinarily, vertical and diagonal members are called WEB MEMBERS, and horizontal (or nearly horizontal members) are called CHORD MEMBERS.

What are the stresses to which these members are subjected?

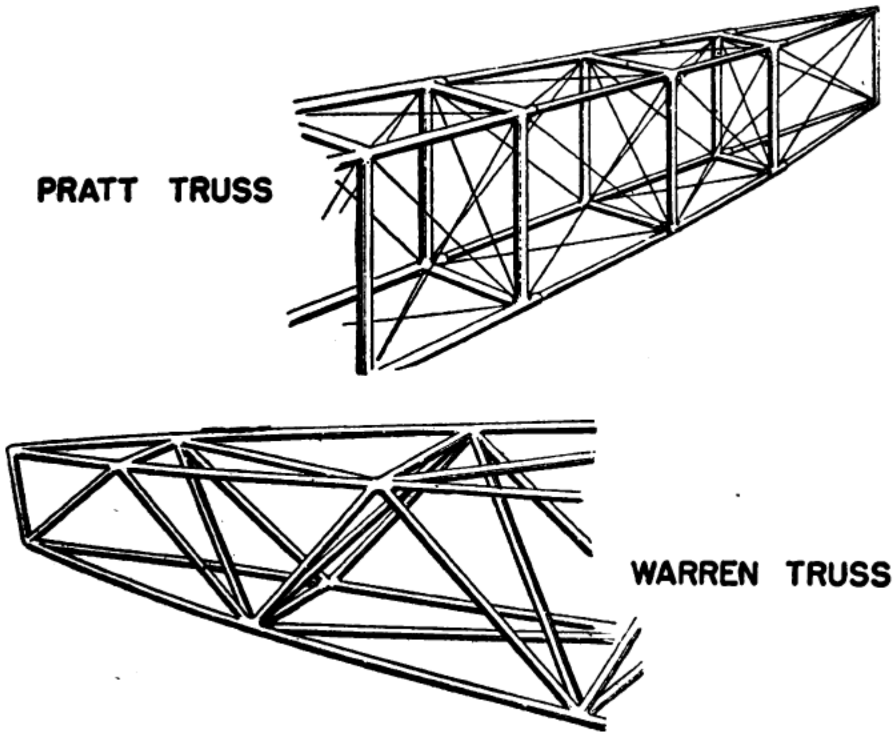


Figure 15.—Pratt and Warren truss.

Strictly speaking, the longitudinal members are subjected to bending, but the tension and compression are much the greater stress. The longitudinal members must carry either tension or compression. The vertical members must be capable of carrying compression loads. The diagonals which are made of wire, are tension members. If the truss is to withstand loads that act either upward or downward, there must be

diagonals crossing each other so that only tension stresses will occur in the diagonals.

In figure 15, you see another type of truss, known as the WARREN TRUSS. Any member of this truss can carry either tension or compression. When the load is acting in one direction, every alternate web member carries tension, the others compression. When the load is reversed, the stresses in the web are also reversed. The web members which were carrying compression in one instance are subjected to tension in another and those which were carrying tension are under compression.

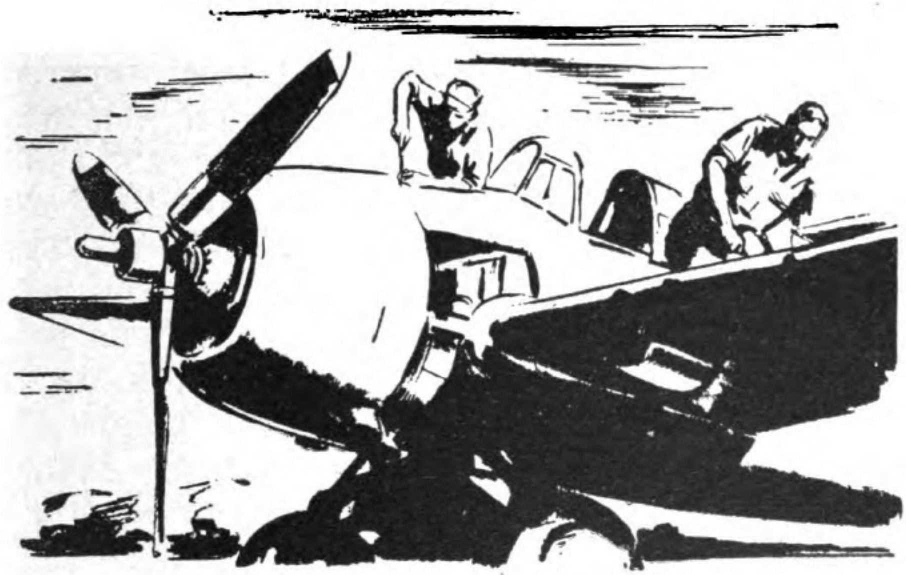
Airplane designers are able to calculate how much load will be applied to each member of an airplane structure under various conditions of flight and landing. They can then figure out how large and strong each member must be. Nevertheless, as a double check the completed airplane is subjected to a "sand-load test." In this test all parts of the airplane are loaded with sand or lead shot in bags—to the weight or force that they will be expected to withstand.

Of course, the structure must be built to withstand much greater forces than the loads to which it is subjected in normal flight. Just imagine, for instance, the tremendous stress on the wings of a Hellcat fighter as it pulls out of a 1,000 foot dive. Consequently, airplanes are designed to withstand from 4 to 12 times the load produced in normal flight. And then, to be on the safe side, certain important structures are built to withstand even greater loads—to provide what is known as a SAFETY FACTOR.

An airplane is designed, then, to be strong enough under any flight conditions to which it is likely to be subjected. Remember, though, this depends upon the various members being in good

condition. For instance, a strip of heat-treated alloy steel 1 inch wide and $\frac{1}{16}$ of an inch thick might easily carry a tension load of 10,000 pounds. However, if the strip is allowed to accumulate rust so that $\frac{1}{64}$ of an inch is eaten away on each side, there will be only $\frac{1}{32}$ of an inch of effective thickness left. The piece would then carry only 5,000 pounds.

Most airplane parts are built of high quality material and made very thin in order to save weight. That means, that any corrosion, rust, scratches, or nicks may seriously impair the strength of a member and cause structural failure, or even collapse of the part in flight. You have a great responsibility in this regard. MAKE SURE THAT THE AIRPLANES YOU WORK ON HAVE THE PROPER CARE.



CHAPTER 5

TYPES OF FASTENINGS

THOUSANDS OF RIVETS

It won't do you much good to have an airplane built of good materials and strong parts unless those parts are firmly fastened together. And you've got to use something more substantial than baled-hay wire to do this.

The metal parts of modern airplanes are fastened together by several different processes. These include RIVETING, BOLTING, SOLDERING, BRAZING and WELDING.

You'll find the most common method of attaching aluminum-alloy sheets to each other on Navy airplanes is by riveting. And it takes thousands of rivets. Most of them have to be put in by hand, too.

A RIVET is simply a headed pin or unthreaded bolt used for uniting two or more pieces of metal.

Look at figure 16. You pass the shank (or body) through a hole in each piece and then form the plain end so as to make a second head tight against the surface of the metal. You should note, though, that it is the shank of the rivet that does the work. The heads prevent the shanks from slipping out of place, but you can pull the metal over the head or break the edges of the head much more easily than you can break the shanks by the shearing action of the plates. This means that you should NEVER use a rivet in a place when the load weight might be carried by direct tension on the head.

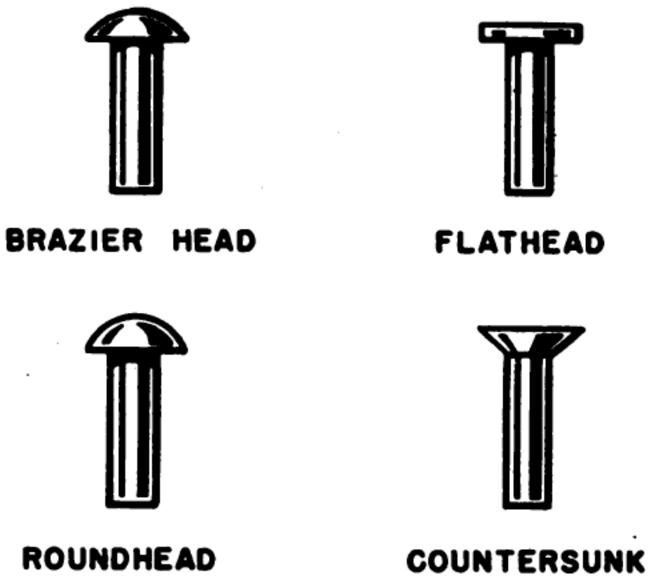


Figure 16.—Types of rivets.

In making a riveted joint, the two sheets of metal are laid in the proper relation to each other and the rivet holes are drilled. As the drilling proceeds, the sheets are clamped together at intervals by a small mechanical device that goes through the holes in the two sheets and holds them together. The rivets are then put in the holes not used for the temporary fastening. Two men, a riveter and a bucker, proceed to head them up. The bucker holds a piece of metal

called a BUCKING BAR or a BUCKING DOLLY against the headed end of the rivet, and the riveter applies a PNEUMATIC HAMMER to the other end. The rapid blows from the pneumatic hammer quickly form another head on the rivet. You can see, though, that riveting is a relatively slow process and may be rather difficult when done in a restricted space.

The job of riveting becomes even more complicated when flush rivets are used. Those are the kind in which there is no projection above the outside surface of the sheet. Despite the additional work required for flush riveting, the use of this type greatly reduces the profile drag, as you learned in the chapter on aerodynamics. In flush riveting, it is necessary to make a dent or depression in the thin metal sheets around the rivet hole so that the tapered head will be flush with the surface. A joint such as this is called a "dimpled" joint such as you see in figure 17.

Figure 17.—Dimpled joint.

SCREWS

SCREWS, like rivets, play an important part in the construction of airplanes. You can use screws of the self-tapping type for fastening fabric to wing ribs, for fastening metal spars to ribs, and for many other purposes.

Such a screw taps the hole it is screwed into and can be driven with any type of screwdriver. It makes its own thread. In using these screws, you have to make sure that the holes are the proper size for the screw used. And you also have to take care that you use the right size of screw for the thickness of metal. A standard type of self-tapping screw is shown in figure 18.

Figure 18.—Sheet metal screws.

NUTS AND BOLTS

If you want to remove a part from an airplane, you don't want it tightly riveted. Consequently, airplane parts which must be detachable are usually fastened with AIRCRAFT BOLTS. Such bolts are made of heat-treated alloy steel and are exceptionally strong. So be sure NEVER to replace an aircraft bolt with an ordinary commercial machine bolt, which has less than half the strength.

Bolts must be SAFETIED to prevent their being loosened by the vibration encountered in flight. Bolts are usually provided with a CASTLE NUT which serves this purpose. A castle nut is simply a nut provided with slots through which a cotter pin can be passed. The threaded end of the bolt is drilled so that the cotter passes through the bolt and through the slot in the nut.

Figure 19 illustrates various types of aircraft locking devices.

Cotter pins are usually spoiled after they have been used once, so you'd better use a SAFETY PIN in cases where it is necessary to remove a bolt at

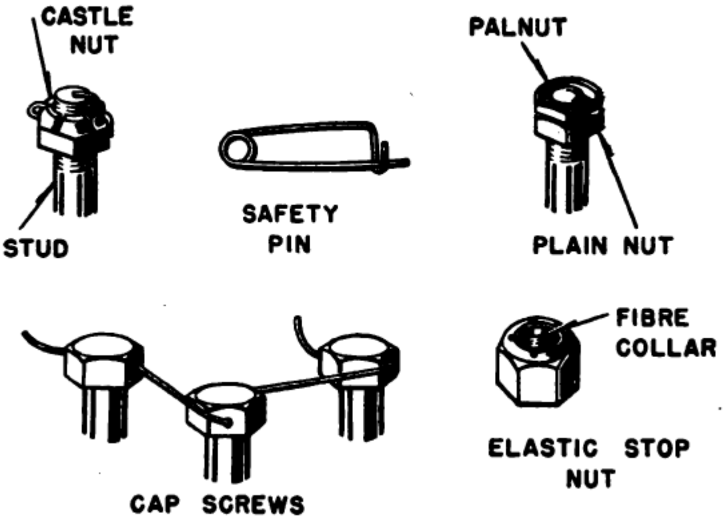


Figure 19.—Aircraft locking devices.

frequent intervals. An aircraft safety pin is made of spring-steel wire and is like the ordinary safety pin you've seen and used around home.

You can also lock a nut by means of a special type of auxiliary nut known as a PALNUT. You'll find this a reasonably satisfactory lock. Another type of nut, known as the ELASTIC STOP NUT, is provided with a fiber collar which serves to lock the nut in place. This locking collar has a hole of smaller diameter than the diameter of the hole of the nut and is not threaded. When the bolt is screwed through the nut, the fiber collar is squeezed apart. The collar then fits tightly around the bolt and eliminates all play between the nut and the bolt. Moreover, this tight wedging of the nut against the bolt prevents the vibration of the airplane from causing the nut to work loose and fall off.

CAP SCREWS are bolts without nuts and are screwed directly into one of the parts being bolted together. You can lock them by passing safety wire through holes drilled in the head. You can also use this method to lock castle nuts in place when they are used on studs. You'll find, how-

ever, that A COTTER-PIN IS A BETTER METHOD for locking nuts or bolts providing you don't have a series of nuts or bolts which could be safetied by the same piece of wire.

A TURNBUCKLE is a device consisting of barrel and two shanks. The forked end has the right hand thread. This device is used to tighten rods and to adjust control cables and the like. You'll find them in many places on aircraft. As you'd expect, they also have to be safetied. You safety a turnbuckle by wrapping a SAFETY WIRE around the terminal or fork, passing it through a hole in the barrel, and carrying it to the other terminal. It is then passed through this terminal and the loose ends are wrapped around the shank as you see in figure 20. Whenever possible, however, you should use two safety wires. Safety wire is a zinc coated steel wire of a little less than $1/16$ of an inch diameter.

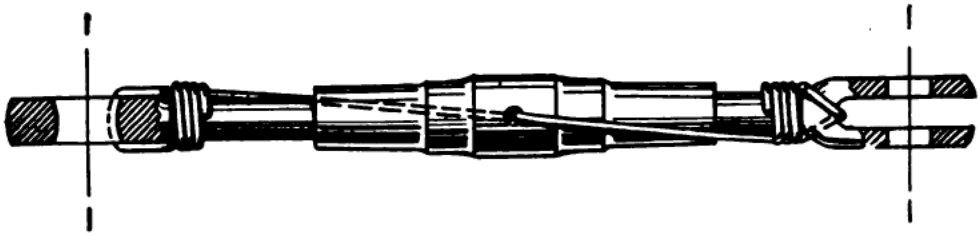


Figure 20.—Safetied turnbuckle.

Sometimes you will find nuts and bolts safetied by means of the common LOCK WASHERS. But this method of safetying is not always dependable and should be used only in fastening small pieces of cowling and other relatively unimportant parts.

DZUS FASTENERS

You need quickly detachable fasteners on such things as inspection panels and engine cowls. One of the most popular types is the DZUS FASTENER shown in figure 21. This fastener consists of a

small stud with a slotted head like an ordinary screw head. The shank is hollow and has a curved slot in it. This part fits into the cowl, panel, or other movable surface.

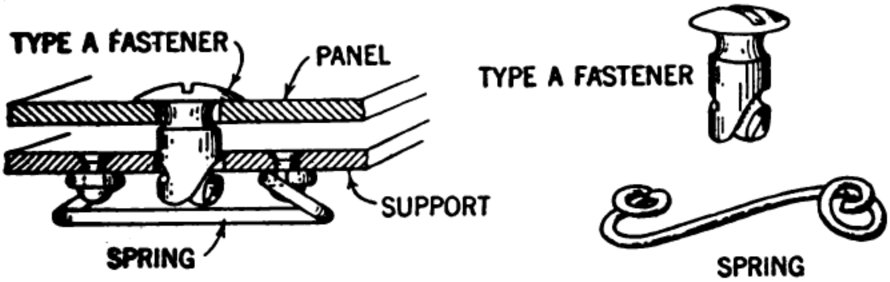


Figure 21.—Dzus fastener.

An S-shaped round-wire spring is attached to the inside of the fixed surface against which the movable surface closes. When you bring the two surfaces together, as in closing the cowl, the nose of the shank enters a round hole in the fixed surface. The slot then engages the spring. Now if you turn the fastener with a screw driver, the spring wire slides up into the slot where it holds firmly until you turn the fastener the other way.

CAMLOC FASTENER

You'll find a device called a CAMLOC FASTENER used for holding two sheets of metal, panels, or other parts together. It consists of a CAM COLLAR, the GROMMET, and the STUD ASSEMBLY, as shown in figure 22.

The cam collar is a forged aluminum receptacle. It is permanently attached to the aircraft structure in a hole which has been either dimpled or countersunk, so that the cam collar does not extend above the mounting surface.

The grommet is the flanged ring which is permanently fastened to the panel or cowling. The stud assembly consists of STUD, CROSS-PIN, SPRING, and SPRING CLIP. You don't have to worry

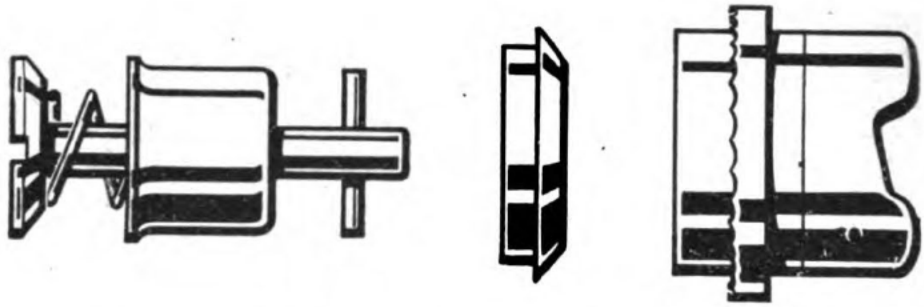


Figure 22.—Camloc fastener parts.

about assembling this unit because it is done in the factory and should never be disassembled. It is designed so that it can be quickly inserted into the grommet by compressing the spring. Once you install the stud assembly in the grommet, it cannot get out until the spring is again compressed.

SOLDERING AND BRAZING

Soft soldering is used where high strength is not considered necessary in a joint. Soft solder is made from a mixture of tin and lead. It melts at a very low temperature. It may be heated either by a heated piece of copper, called a soldering copper, or by a gasoline blowtorch. The parts to be soldered are coated with a flux, often made of muriatic acid (though on cables, a noncorrosive paste is used), before the solder is applied. The flux cleans the parts and frees them from grease or dirt which might prevent the solder from sticking.

For stronger joints, hard, or silver solder is used. It is made from almost pure silver and requires either a gasoline or illuminating-gas blowtorch, or an oxyacetylene torch for heating.

Brazing consists of joining steel parts by the use of brass or bronze. In this process the metal is melted by means of an oxyacetylene torch. As in soldering, a flux is necessary. Usually it is borax. On cooling, the melted brass or bronze adheres firmly to the parts being joined. Although brazing makes a stronger joint than soldering, you won't find it used where extremely high strength is necessary.

WELDING

For more strength, you depend on WELDING. That's the process of joining two parts by actually melting them into each other. If you weld a joint properly, it's nearly as strong as the original material. Bear in mind, however, that you can make a metal weak by overheating or heating in the wrong way.

Besides forming a strong joint, welding is quick and comparatively inexpensive. Consequently, it is used more than any other method for fastening steel airplane parts together—provided they don't have to be separated again.

Probably the most common method of welding is that in which the metal is melted by means of any oxyacetylene torch. By this method, oxygen and acetylene are mixed and ignited at the nozzle of the torch. The oxygen causes the acetylene to burn with an intense heat of several thousand degrees Fahrenheit. The welder must manipulate the torch and the rod of filler metal very carefully in order to melt and join the metal properly without burning it.

OXYACETYLENE WELDING is used in the construction of steel-tube fuselages, landing gears, engine mounts, and in many other places. It is also used in the construction of aluminum fuel and oil tanks. The edges of the aluminum sheets form-

ing the sides and ends of the tanks are melted together by means of the torch, thus making a tight and durable joint.

Welding is done with an ELECTRIC ARC. You'll find, however, that this method is used mostly on heavy work and in factories. It is not used much at present in the repair of airplanes and parts. In electric welding an electrical terminal is attached to the part that is to be welded. The other terminal is attached to the handle which carries the welding rod. As the rod is brought in contact with the part to be welded and then drawn away, an electric arc leaps from the welding rod to the work. The heat of this arc melts both the work and the welding rod. The joint is made by applying the melted welding rod to the work, along the seam. Thus the heat melts the pieces that are being joined and they are fused together.

The third type of welding is known as SPOT WELDING. It is used primarily for fastening together stainless-steel sheets or aluminum-alloy sheets. The sheets are pressed together by a pair of electrodes, and the current is passed through them and through the sheets. This current causes the sheets to melt because of the heat produced by the resistance of the sheets to the passage of the current. Since the sheets are being pressed together at the point where they are melted, they are fused to each other at one spot. That's where the name "spot" welding came from.

If there is a long seam to be made, rollers are often employed as electrodes. It is possible to weld as many as 900 spots per minute by means of these rollers. Sometimes you'll hear this rapid form of spot welding referred to as "shot" welding. It's worth remembering, too, that spot or shot welding may be used on heat-treated material without softening it or heating it to such a degree

as to spoil its strength. That's the reason this type of welding is used with stainless steel and heat-treated aluminum alloy. Both of these metals could be weakened seriously by torch welding.

GLUES

You aren't going to find many wooden parts on Navy airplanes except certain trainers. But when it is necessary to fasten wooden parts together, it's usually done with glue. The glue used in furniture construction is ordinarily hot glue. Hot glue, however, is not waterproof and must be kept hot, not only when applied but also when the parts are clamped together. Therefore, you see why it is not practical for use on airplanes.

On airplanes, however, a cold glue is used. The most common one used in aircraft work is called CASEIN GLUE. It comes in the form of a white powder, and is mixed with cold water to the consistency of thick cream. Yet it is WATERPROOF. The parts to be joined are coated with the glue and then clamped together. Pressures ranging from 125 psi, for spruce and other soft woods, up to 200 psi, for the harder woods are utilized. The glue will set in about 4 hours, but the parts are not considered ready for use for about 24 hours.

CHAPTER 6

CONSTRUCTION

LIGHT BUT STRONG

Navy airplanes have handed the enemy plenty of punishment in the Pacific. But they've been on the receiving end, too. Airplanes have been punctured by considerable gunfire and still have brought their pilots and crews home. Navy fighters—like the Corsair and the Hellcat—have actually been known to return from dogfights with as many as 20 to 30 holes from 20-mm. cannon in their fuselages and, after being patched up, to go out and shoot down more Japs.

You can be sure it isn't all luck or good piloting that keeps Navy airplanes flying. Modern types of construction provide part of the answer.

For instance, what do you suppose would happen to an airplane with the old truss type fuselage if a bullet struck a longeron? Ten to one the fuselage would collapse in midair. But a strongly supported metal fuselage might take such a rap and still hold up.

"What's the secret?" you ask. No secret. Just the difference between an airplane that depends upon a FEW heavy members for strength and one that has its strength widely distributed in an all metal shell. So look over an airplane's fuselage and see how it is constructed.

FUSELAGE

The FUSELAGE provides space for the fuel and oil tanks, equipment, controls, cargo, crew, and passengers. Fuel lines, carburetors, magnetos, ignition leads, and instruments must be arranged so that inspection, repair, and replacement are easily accomplished. The fuselage must, in addition, have attachments for the wings, tail surfaces and landing gear—also readily removable. It's got to have strength to receive the lift loads and landing loads. And finally, the less resistance it offers to the air the faster your airplane will fly. Then, if the fuselage permits your pilot good vision, too, it will be all the easier for him to play TAPS FOR THE JAPS.

There are three general types of fuselage construction. They're called TRUSS, SEMIMONOCOQUE, and MONOCOQUE.

Truss-type fuselages usually have four longerons (tubes) running from the engine mount to the rudderpost. These longerons provide the primary strength members. The side trusses may have VERTICAL STRUTS and cross brace wires or cross tie rods, in which case they are PRATT TRUSSES. The longerons are usually made of several different sizes of steel tubes. They are so constructed that the smaller tubes will fit within the larger—telescope fashion. Thus a smaller tube may be used near the tail where the stresses are less. The fuselage struts are also of steel tubing, larger

near the forward end of the fuselage, smaller toward the rear. All are welded in place. At the points where the fuselage struts are attached to the longerons, a flat plate or fitting is usually provided for the attachment of the tie-rod terminal. You can aline this type of fuselage by adjusting the tie rods.

The bays are cross-braced in the top and bottom, the two sides, and the two ends of each bay. You'll often hear these wires, or tie rods, referred to as BULKHEAD WIRES. Of course, there can't be any bracing wires at the point where the cockpit is located. But if the other bays are completely braced on all six sides, the fuselage will remain rigid, even though cross wires are omitted in the cockpit.

If the crosspieces or web members are capable of taking both tension and compression (pull and push), the fuselage is called a WARREN TYPE TRUSS. In this type the various members made of steel tubing, welded in place, or aluminum alloy angles or channels, bolted or riveted in place. There's one definite advantage to the aluminum-alloy construction. If a strut or a crosspiece is damaged, it can be replaced without welding.

Fabric covers are usually used on the truss-type fuselage. You can see, though, that if the cover were applied directly to a fuselage of this type construction, it would fall into all sorts of valleys and ridges. It wouldn't look well, but MORE IMPORTANT it wouldn't be efficient aerodynamically. And you know how important a smooth surface is on an airfoil. What's needed is some way of holding the cover in smooth lines away from the structural members. This is accomplished by means of FAIRING STRIPS, which run the length of the fuselage in line with the direction of flight. The top of the fuselage is usually

provided with a number of side members arranged in the form of a curve, or with a single sheet of aluminum alloy, which is likewise curved.

This curved upper portion is referred to as a TURTLEBACK. It doesn't have anything to do with the strength but is simply a fairing, or a structural section designed to produce a smooth surface and reduce drag.

Now, what about the MONOCOQUE and SEMIMONOCOQUE types of fuselages? "Monocoque" is another one of those French words which you find used so often in describing airplane parts. "Mono" means one, and "coque" means shell. And that's just what a monocoque fuselage is—a

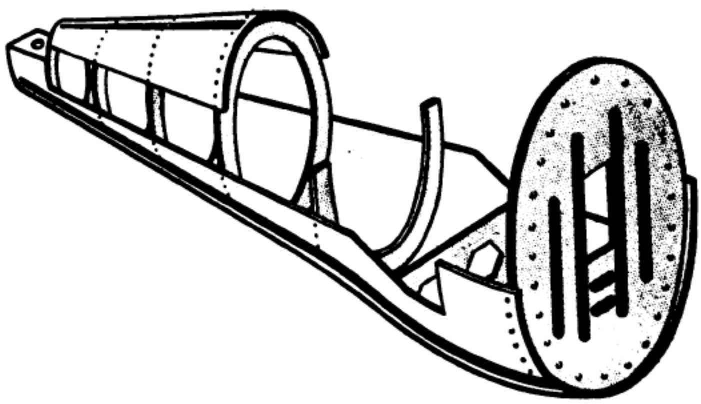


Figure 23.—Monocoque fuselage.

single shell (see fig. 23). Usually it's constructed of aluminum alloy. In the true monocoque all the stresses are carried by the shell or skin proper. In the semimonocoque, some of the load is carried by the skin and some by longitudinal (lengthwise) members, called STRINGERS.

Most of the so-called "monocoque" fuselages are really of the semimonocoque type. This type of fuselage consists of frames (sometimes called bulkheads), the stringers, and the skin or covering. In building such a fuselage the frames are clamped in the proper relationship to each other

on a construction form called a "jig," the stringers are attached to the frames, and the skin is riveted to the stringers. The skin is usually applied in fairly narrow strips for convenience in handling. Since the skin must be riveted to the stringers in any case, it is only a little more trouble to make a joint in the skin at each stringer. Thus the rivets which attach the skin to the stringers also attach the pieces of skin to each other. Heavier pieces of aluminum alloy, or, occasionally steel, are riveted to the skin. This is usually on the inside at points of high stress, such as at the wing attachments and the landing gear.

What are the advantages of monocoque fuselages?

First, they're perfectly streamlined, particularly if flush rivets are used. You know how important flush rivets are in eliminating drag. Monocoques are fireproof, a fact that has saved many airplanes in these days of fiery tracers. They're unaffected by climatic conditions, provided the proper protective coatings have been applied. MINOR repairs, such as patching bullet holes, are easily made. In general, too, monocoques can absorb much greater punishment than can a truss-type fuselage.

On the other hand, monocoques have the disadvantage of being difficult to repair in the case of SERIOUS damage.

ENGINE MOUNTS

Engine mounts are used to attach the power plant to the airplane. On most single-engine airplanes, they are mounted on the front end or nose of the fuselage. On multiengine airplanes, however, the engines are normally mounted on engine mounts such as that shown in figure 24.

The primary consideration in design of engine mounts is to have the engine and its equipment accessible for maintenance and inspection. You'll find that engine mount frameworks are constructed in most cases of welded chrome-molyedenum steel tubing. Forgings of chrome-nickel molybdenum are used for the more highly stressed fittings.

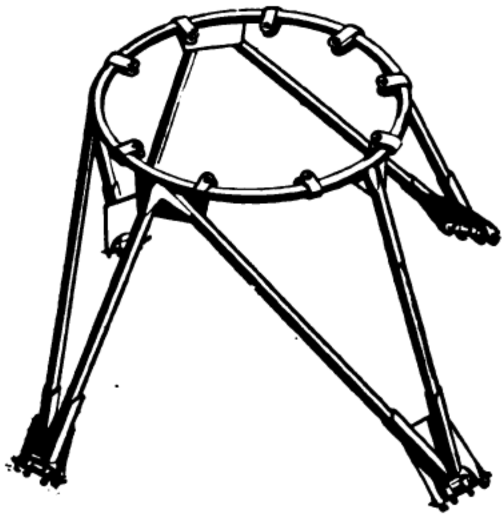


Figure 24.—Engine mount.

The location of the engine mount will vary, of course, on different airplanes. But it is attached either at, or just forward of, a flametight fireproof bulkhead, separating the engine compartment from the rest of the structure. Vibrations from the engine will be transmitted to the engine mount and through it to the aircraft structure unless some device is used to clamp them out. These devices are usually rubber cushions or pads installed where the engine is bolted to the mount.

WINGS

The wings of an airplane provide the principal lifting and supporting surface of the aircraft in flight and they've got to be strong. The wing group also includes struts and wires used to brace the wings, but you won't find many of these on present day naval aircraft. Most of the Navy

airplanes which are used in the war theaters have CANTILEVER wings as shown in figure 25. That means they have no external bracing by wires or struts. And it means too that the construction of the wing must be exceedingly compact and strong.

In its simplest form, however, a wing is a framework consisting chiefly of SPARS and RIBS. The spars are the main members and extend lengthwise of the wing. This means, you see, that they're at right angles to the fuselage. All the load that is carried by the wing is ultimately taken by the spars. In flight, the force of air acts against the cover. From the cover it is transmitted to the ribs, and by the ribs to the spars.

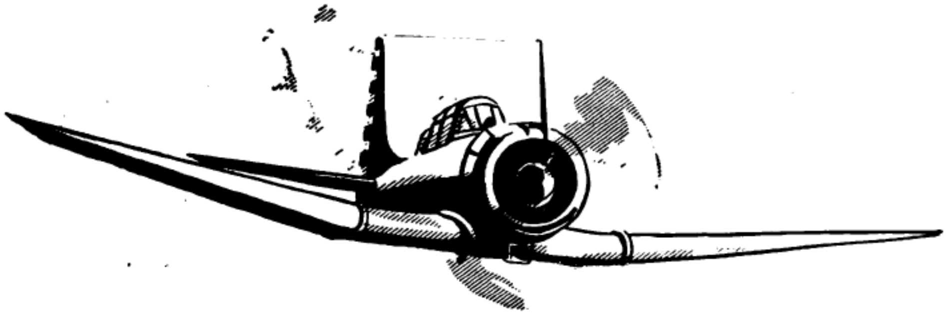


Figure 25.—Cantilever wings.

Wing construction varies greatly, depending on the type of airplane. But most conventional wings, particularly those covered with cloth, have two spars, one near the front or leading edge and one about two-thirds the distance to the rear or trailing edge. Of course, the wings on military airplanes are covered with metal and these sometimes have as many as five spars. In such cases you'll find the ribs either are omitted entirely or are made up of a number of short sections fitted between the spars. In addition to the main spars, some wings are built with a false spar that carries the aileron.

As you have already learned, spars may be made of either wood or metal. But even in cases where wood is used, you'll find that some parts are made of metal. Some wings may have wooden spars and metal ribs, and may be covered with wood, cloth, or metal skin, or a combination of these.

In training-type airplanes the spars are usually made of wood and have either a solid rectangular cross section, an I-beam section, or a hollow box section. You'll see what these various types look like in figure 26. The solid section is probably most often utilized, although the I-beam is second in popularity. If the spars are metal, they may be made of aluminum alloy, of either I-beam or truss type. Or they may be made of steel, either steel tubing or steel structural shapes (such as L-sections or T-sections).

A MULTISPAR WING, as the name implies, has several spars as shown in figure 27. Most metal-covered wings are of this type.

Another type of construction which has been used in planes of moderate speed is the MONO-SPAR WING such as you've already looked at in figure 25. As you'd guess from the name, in this type there is only one main spar. But the entire nose section, back to 20 or 30 percent of the chord length from the nose, is built of metal. The rear portions of the ribs are attached to the heavy

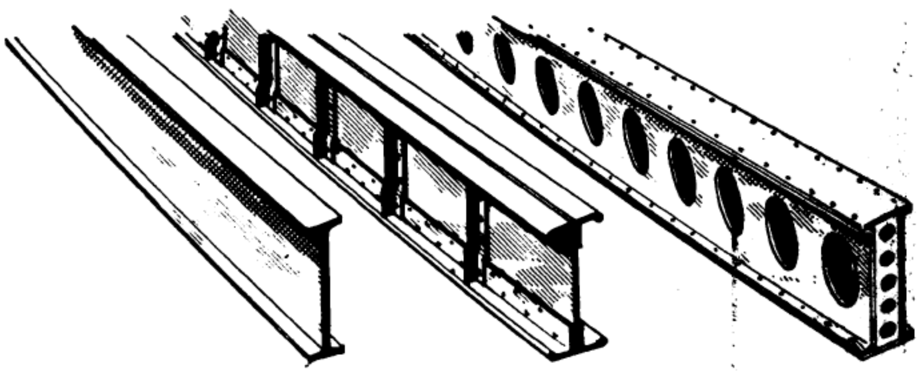


Figure 26.—Types of spars.

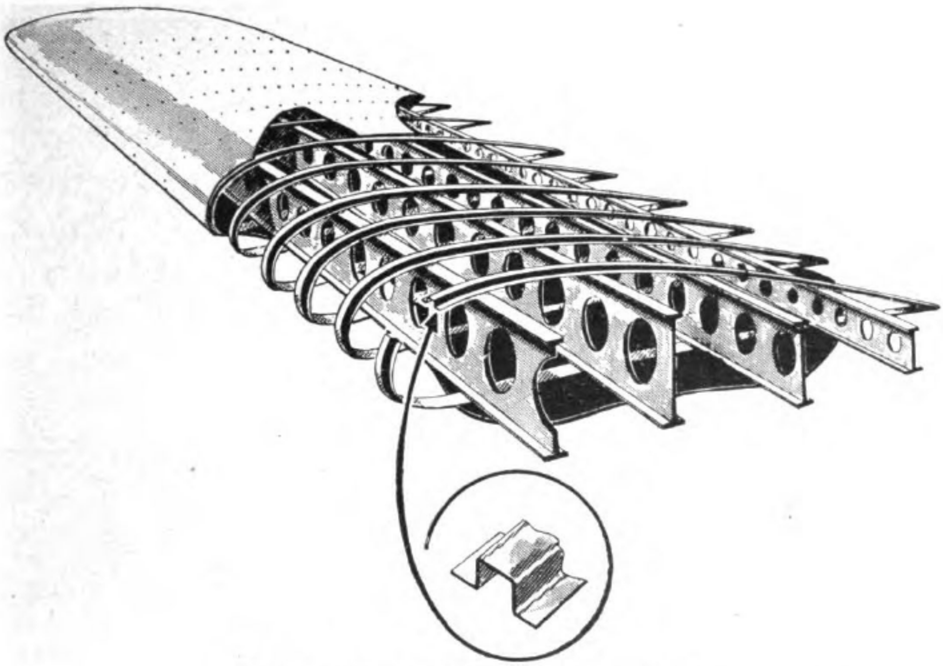


Figure 27.—Multispar wing section.

spar and the structure is covered with fabric from the spar to the trailing edge. The nose section carries all the lift and drag loads.

You can see, though, that the monospar wing has the same disadvantage as does a truss-type fuselage—too many eggs in one basket. In other words, if enemy machine gun bullets weaken this single spar, it may mean good-bye wing. But the multispar wing, like the monocoque fuselage, can take considerable punishment from gun fire without collapse. Furthermore, a fabric cover would not withstand the high speeds of modern fighters unless the ribs were so close together that no advantage in weight would be gained by using the fabric.

Now take a look at figure 28 to see how the shape of the wing is maintained by the ribs, which support the covering. The main ribs, which give the wing its shape and carry the lift loads transmitted by the covering, are called FORM RIBS.

You'll usually find that a wing has other short ribs, called NOSE RIBS, to insure that the nose sec-

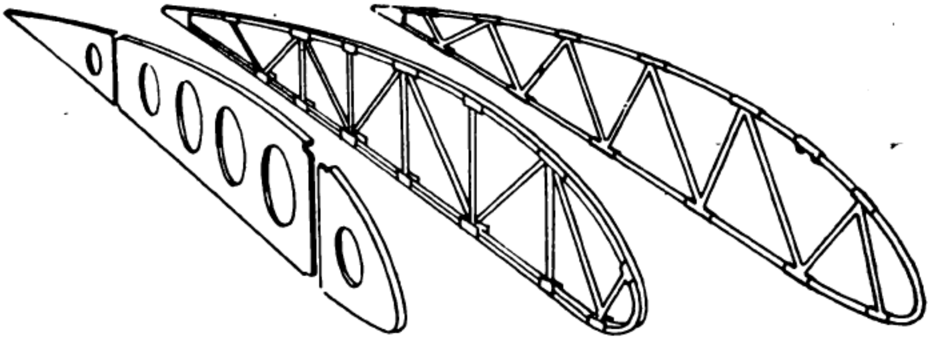


Figure 28.—Types of ribs.

tion of the wing maintains its shape in flight. The air force on the nose section, as you've learned, is much greater than elsewhere thoughout the wing. That's why these additional supports are needed.

Often, too, the entire forward portion of the wing back to, or even aft of, the front spar, is covered with plywood or metal to assist in maintaining the contour. Ribs, like spars, may be made of various materials, but the most common are wood or aluminum alloy, though in rare cases steel has been employed.

Of course, the wings of combat airplanes are almost always covered with metal, and the covering or skin carries a certain portion of the loads, particularly the drag load. Metal covered wings are usually of the multispar type and often, in fact, have no ribs at all. Where the ribs are omitted, there is usually an aluminum alloy C-section or L-section, bent to the proper shape and resting on the spars, to maintain the proper airfoil section.

The shape of the outer end of the wing is maintained by a strip of wood or metal called the WING-TIP BOW. The piece that runs along the leading edge is known as the LEADING-EDGE STRIP, and the piece that runs along the rear ends of the ribs is called the TRAILING-EDGE STRIP.

There's another force acting on the wing that must be compensated for. It's a push on the wing from the front and pull from the rear. Consequently, units called COMPRESSION RIBS are necessary. These take the compression load between the front and rear spars. They are heavy ribs and may or may not have the contour of the wing as you can see in figure 29. Together these compression ribs make up what is called a DRAG TRUSS. Oftentimes the compression ribs are simply round steel tubes. In a wooden wing they are usually made of plywood and spruce, with a box or rectangular section. In this case they're called box ribs. The compression rib at the inner end of the wing is referred to as the ROOT RIB or BUTT RIB.

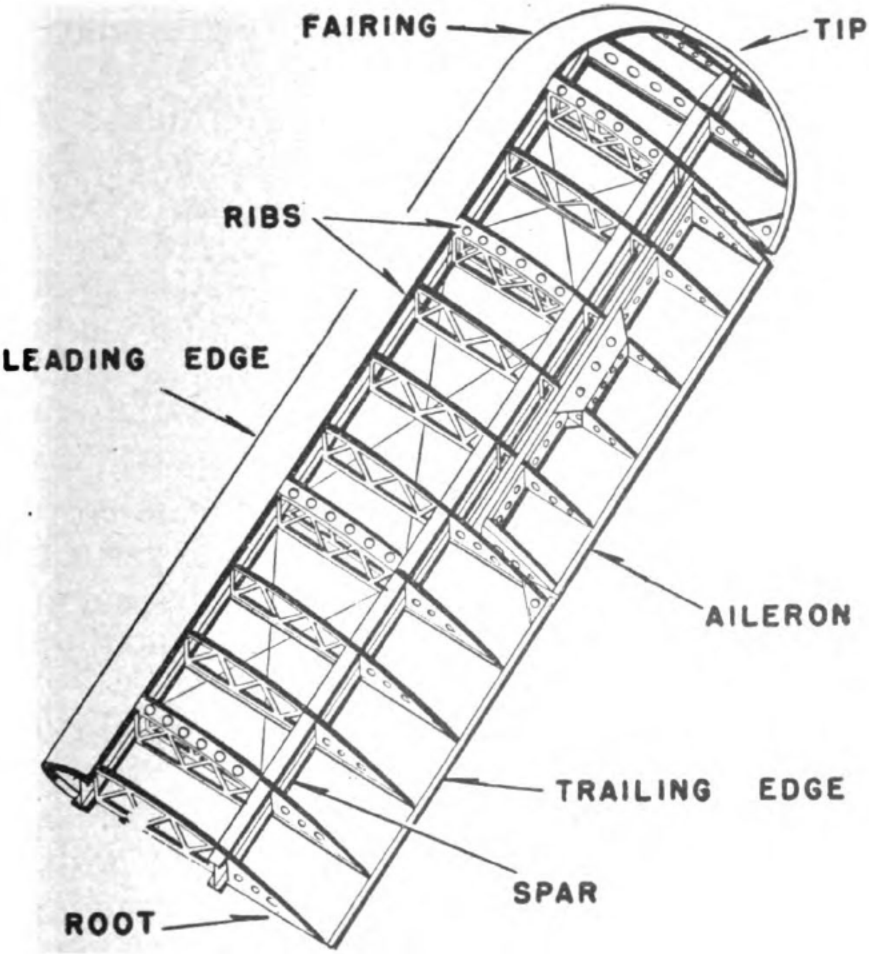


Figure 29.—Wing construction.

Bracing wires, called drag wires, are also needed. You'll sometimes find them distinguished by calling the wires that run from the inner front to the outer rear the drag wire, and its mate, which runs from the inner rear to the outer front, the antidrag wire. In some cases, you may find that a diagonal strut is used instead of two wires. The strut, of course, may carry either tension or compression.

If the wing is covered with metal, the drag truss is usually eliminated entirely. The metal covering is used to keep the wing from losing its shape or being pushed backward by the force of the air. This is what is known as stressed skin construction.

All modern combat airplanes use cantilever wings (without outside struts, you remember). There are several reasons for this. First, since a cantilever wing must necessarily be thicker to provide adequate strength, it provides a good place to house the landing gear when the wheels are retracted. Fuel tanks are also put in the wings and this leaves the fuselage clear for the crew and other equipment. Furthermore, since the cantilever wings have no external bracing in the form of interplane struts and wires, their resistance is lower even though the airfoil is of the thick type. And, of course, they're safer for combat work, since one bullet through an interplane strut might readily cause it to collapse with consequent loss of the wings. The same would be true if one of the lift wires were cut.

Navy fighters, dive bombers, and torpedo planes have metal-covered cantilever wings. But some patrol planes and trainers still use fabric covering. The fabric is usually supplied in widths of 36 inches. Strips of this width, long enough to extend entirely around the wing from the trailing

edge over the nose and back to the trailing edge again, are stitched together with a LOCK SEAM. Sometimes the cover is wrapped around the wing and then sewed by hand along the trailing edge. There's another way to do this, too. It's by stitching the cover together in the form of an envelope. Then, you can slip it on the wing from the outer end.

After the cover is on the wing, a strip of reinforcing tape is laid on each rib, extending—like the cloth—from the trailing edge, over the nose, and back to the trailing edge again. The covering is then stitched to each rib with lacing cord. Usually the cord is passed entirely around the rib, and each stitch is tied with a special knot that will not slip. Thus, if any stitch is broken the others will still remain fast. You'll find that the spacing of the stitching varies from ½ of an inch to 3 inches, depending upon the speed of the airplane.

After the rib stitching has been completed, the wing is given one coat of dope. Then the stitches are covered with a wide strip of tape, made of the same material as the fabric and with the edges scalloped or notched to make them stick down better. This "rib tape," as you'll hear it called, is pasted on with the dope. The entire wing is normally given six coats of dope on the lower camber and seven coats on the upper camber. It may be rubbed with a light abrasive after the third coat so that the final finish will be very smooth. Patches of fabric or canvas attached to fabric are also doped on at points where wear is likely to occur.

TAIL SURFACES AND AILERONS

For the most part, the construction of tail surfaces and ailerons is similar to that of the wings.

You'll find that practically all fixed tail surfaces are provided with two spars and a series of ribs. Usually the fixed tail surfaces in all-metal airplanes are covered with fabric, even when the rest of the airplane is metal covered.

In small, light airplanes, the fin and stabilizer are usually covered with fabric, and sometimes the front member acts as the front spar. In other cases, there is a definite front and rear spar and a leading-edge strip as in the wing.

You've already found out the way the control system works, so you can see that the movable surfaces must have a spar at the front end in

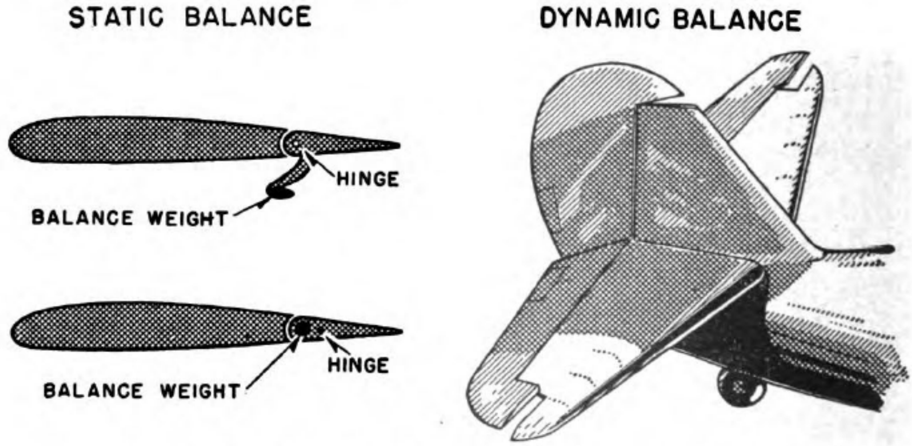


Figure 30.—Static and dynamic balancing of control surfaces.

order to have a place to attach the hinges and control horns. Usually you'll find that there isn't any additional spar. This means the ribs extend from the front spar to the trailing edge. In many airplanes the front spar consists of a steel or aluminum alloy tube to which the ribs are attached. The contour is usually formed by tubes, either round or streamlined. The ribs are either small tubes or light sheet stampings. Sometimes sections of aluminum alloy may be used for eleva-

tor ribs combined with a built-up sheet aluminum alloy spar.

AILERONS are constructed in much the same way as are the elevators and rudder. The ailerons, even on a metal-covered wing, are usually covered with cloth fabric. You were just told that fabric covering on wings would not stand up under the high speed of the modern airplane. "So how come," you ask, "that fabric can be used on the ailerons?" Actually, the ailerons are not subjected to the high forces imposed on the remainder of the wing, and, consequently, the fabric cover DOES stand up. Moreover, the ailerons can thus be made lighter and can be much more easily balanced. Controls may be balanced EITHER aerodynamically or statically. In the first case, the balance is achieved by locating the hinge somewhat back from the leading edge. Thus, the surface, which is acted upon by the force of the air striking the section forward of the hinge helps the pilot in moving the surface. In utilizing a static balance, a weight is located at some position forward of the aileron hinge as shown in figure 30. This weight ordinarily may be in the form of a small streamlined shape carried on an arm projecting from the aileron, or it may be a weight in the forward section of the aileron itself.

CHAPTER 7

LANDING GEAR

FOR LAND, SNOW OR WATER

An airplane may be moving from 30 to 100 or more miles per hour when it comes in for a landing. Even if the pilot makes a perfect landing, the shock to the undercarriage is great. But if the landing is a bad one or the surface rough, the stresses are dangerously high. That's why a good landing gear must be able to withstand extreme shocks, and at the same time prevent those shocks being transmitted in full force to the rest of the airplane.

Modern airplanes, of course, land on all kinds of surfaces—snow, water, and hard surfaces such as runways and the decks of airplane carriers. If the aircraft is to be operated from snow, a ski type of undercarriage is utilized. If from water, the float type gear is used. If the aircraft is a flying boat, however, the main body or hull keeps the airplane afloat. And, of course, if the airplane is to be operated on hard surfaces, you'll find it equipped with wheels. Then there are the amphibious airplanes which can land on either land or water. Figure 31 shows the various types of landing gear arrangement.

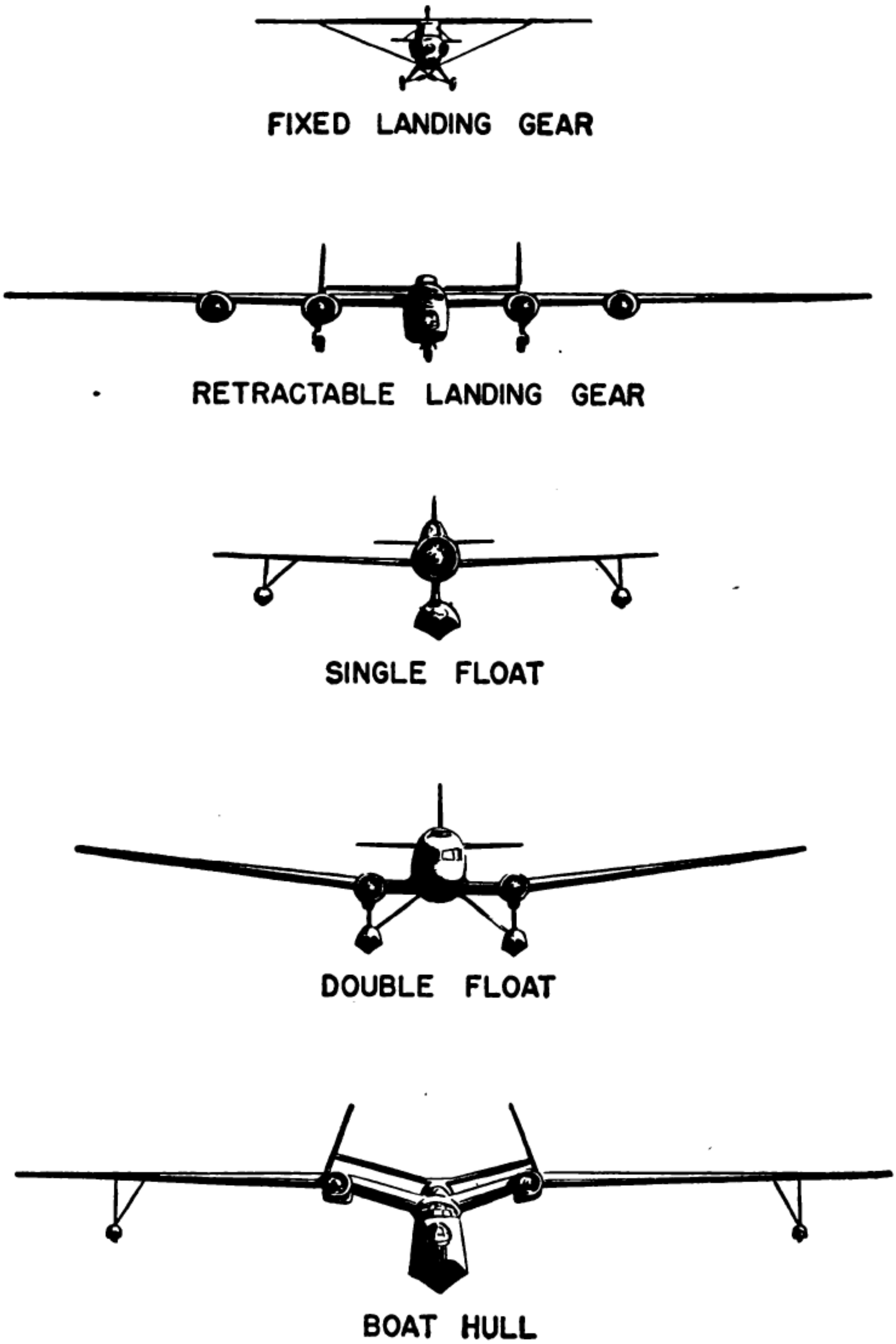


Figure 31.—Types of landing gear.

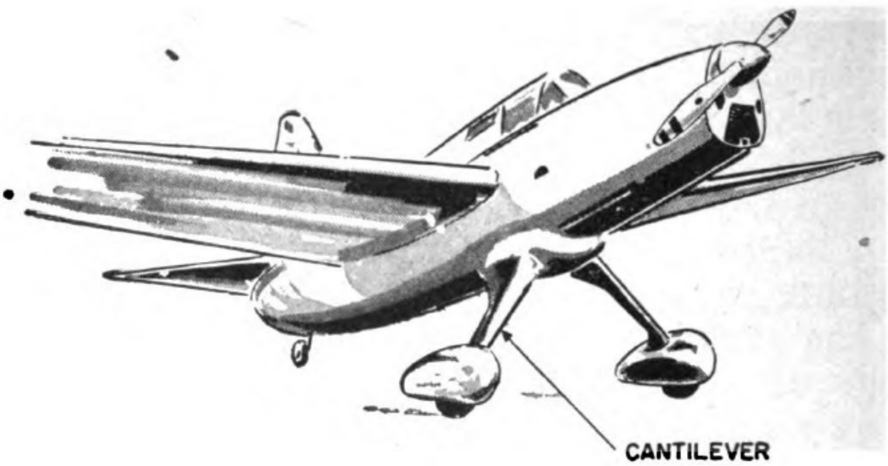
A wheel type landing gear consists of a pair of wheels attached by struts to the fuselage slightly ahead of the airplane's center of gravity.

There is also a tail wheel, although you may still occasionally see a light trainer with a tail skid. This skid is a stiff metal support with a hardened steel shoe attached. When the pilot brings down his airplane so that it alights on all three wheels (or the two wheels and the tail skid) at the same instant, he makes a "three point landing."

The simplest type of main landing gear consists of a pair of vee-struts, with rubber-tired wheels on each. You won't find the continuous axle between the wheels, however. That's because such an axle might strike small objects on the ground and cause the airplane to nose over. The main gear has to be high enough to give the propeller good clearance from the ground when taking off. And the tail gear must be low enough in proportion to the main gear to allow the airplane to land smoothly on all three points in an approximately stalling position. Finally, the main gear has to be attached to strong members of the fuselage, so that the landing shock is distributed as widely as possible throughout the main body structure.

The tricycle type landing gear has its third wheel at the nose instead of at the tail. Then, of course, you have to have the main landing gear wheels behind the airplane's center of gravity. Practically all of today's Navy airplanes, however, have the conventional two-wheel landing gears.

Wheel-type landing gears are either FIXED or RETRACTABLE. You've already found out how the retractable type of gear, which folds up in the wings, reduces the drag and permits the airplane to travel at a greater speed. If you're going to be perfectly accurate, though, you'll have to say that even the fixed type of gear is not completely fixed. The reason goes back to the question of



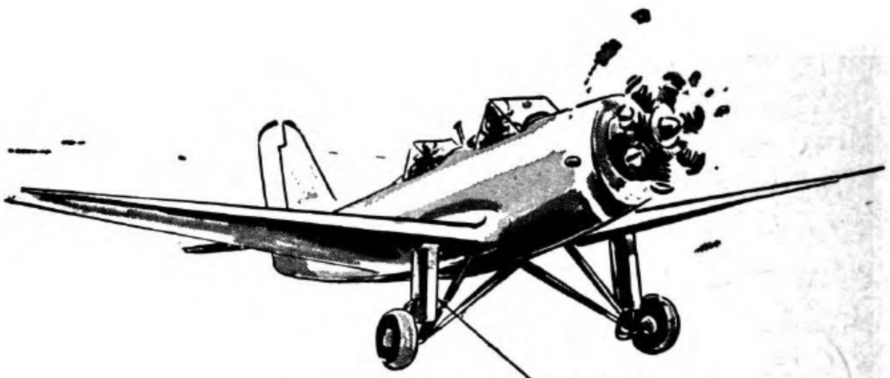


Figure 32.—Cantilever and braced landing gear.

ABSORBING STRESSES—the question with which we started. Actually, the wheels must move up and down while landing or while taxiing in order to absorb the shocks.

Remember the word "cantilever" as applied to wings? Well, it has a similar meaning when used to describe landing gears—that is, extended from a support without braces. Figure 32, top, shows a cantilever landing gear of the retractable type. The braced and fixed type is shown in figure 32, bottom.

SHOCK ABSORBERS

The various types of shock absorbers may be divided into three classes—HYDRAULIC AND PNEU-

MATIC, RUBBER (disk, ring, cord), and SPRING TYPE (coil or leaf). But you'll find that Navy airplanes and most modern airplanes use what is known as an "oleo" or oleo-pneumatic strut to absorb the shocks of landing and taxiing. These struts depend for their shock absorbing qualities upon the facts that oil is not compressible and that its viscosity (internal fluid friction (limits its speed of movement when forced through a small hole. The fluid (or oil) lubricates the sliding parts as well as provides absorption of landing shocks. Moreover, the type of fluid used in the struts does not thicken in cold weather.

The basic parts of the oleo strut are a piston and a cylinder. The lower part of the cylinder is filled with fluid, while the upper chamber is filled with air. The piston is provided with a small hole (or holes) in the head. When the airplane lands, the fluid is forced through the small hole. The strut is thus allowed to telescope, or shorten slowly, and absorb the shock. In some struts, a metering valve opens as the piston moves upward and allows the fluid to enter the air chamber to obtain the same cushioning effect.

In earlier airplanes, the shocks of landing were absorbed through elastic cord or rubber disks. Of course, the rubber absorbed the shock all right, but it also recoiled with almost as much force as had been used to stretch or compress it. You can see what would happen. In a rough landing, the recoil of the rubber tended to throw the airplane back into the air again and often did. And that's no fun for anybody in the airplane. With an oleo strut, however, there is little recoil tendency to make the airplane bounce. This is an important advantage of the oleo strut.

But how are the shocks of taxiing absorbed after all the oil has passed from the cylinder through the piston?

The strut shown in figure 33 is provided with a compressed air or a coil spring arrangement. This prevents the piston from ever reaching the end of the cylinder and so helps absorb the taxiing shocks.

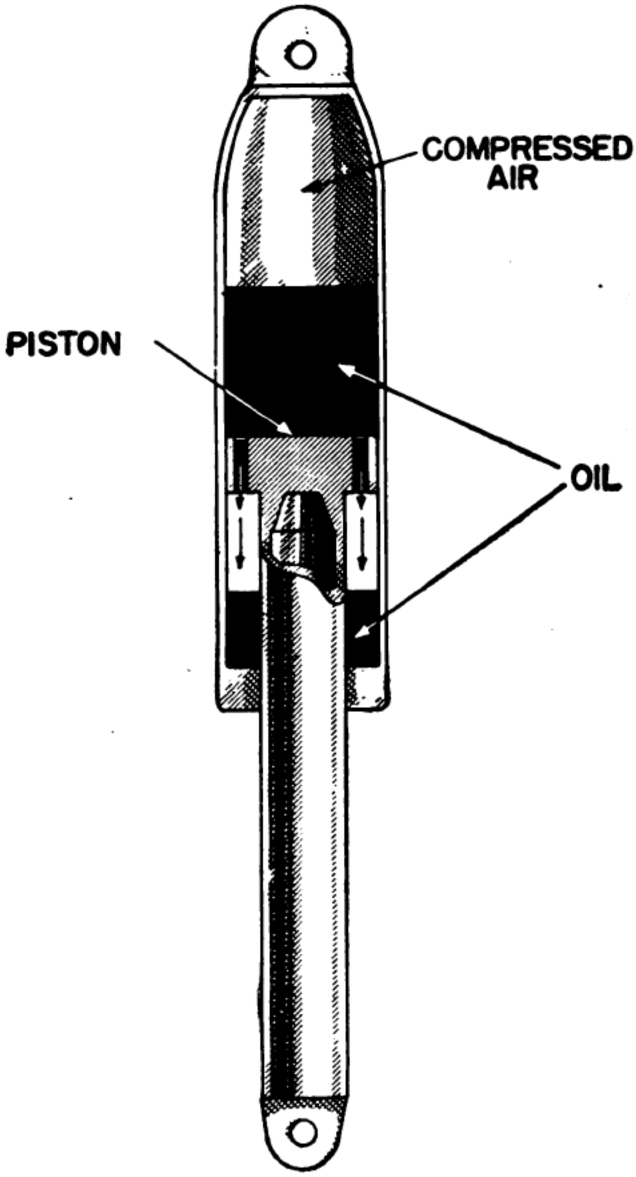


Figure 33.—Oleo-pneumatic strut.

Of course, the tires of the airplane also act as shock absorbers to a certain extent, particularly in taxiing. The low pressure tires, used in some airplanes, are called "air wheels." Such tires do

not use a wheel proper, the tire being attached directly to the hub, or sleeve which revolves on the axle. The air pressure is very low, usually from 5 to 7 pounds per square inch. Air wheels are excellent on muddy or soft fields. But tires, like rubber shock absorbers, store the impact rather than dissipate it, and kick the airplane back into the air after a rough landing.

Tail wheels are usually provided with shock struts similar to those on the landing gear. Tail wheels are also retractable. Most tail wheels are either STEERABLE OR FULL SWIVELING. If they're steerable, they're connected to the rubber pedal so that they turn in the same direction that the rudder turns and thus assist in taxiing. Also, tail wheels of this type are usually provided with a lock that will hold them in a fore and aft position for landing and take-off.

WHEELS AND BRAKES

There are two types of wheels—the DISK and the CAST type. The disk types are made from aluminum-alloy disks which are attached to the rim and the bearing. On the inner side of the wheel a steel brake drum is mounted. Low-pressure tires, however, require wheels of small diameter. These are cast, usually of aluminum alloy also, and have insert brake mechanisms.

The brakes are operated by the pilot from the cockpit by means of a toe or a heel pedal on the rudder. They can be applied individually. That makes it easier to taxi the airplane. Either wheel can be held or slowed down, which means the airplane can be turned or maneuvered easily.

The brake assemblies are arranged between the rims and the hubs. You'll find that most are of the multiple-plate type, although single-plate and shoe brakes are often used on lighter airplanes.

Disk-type brakes consist of alternate bronze and steel disks, or rings which are sandwiched in a metal casing. The bronze disks may be keyed to the wheel so that they rotate with it. The steel disks would then be keyed to the fixed portion, which is attached to the strut. When these disks are forced together—either by a mechanical or hydraulic control—they rub against one another and so provide the braking action.

Shoe brakes are divided into two classifications, SINGLE SERVO and DUO SERVO brakes. The term "servo" refers to the use of the rotary motion of the wheel to further expand and apply the brake. These brakes are illustrated in figures 34 and 35.

In single servo brakes, the servo action is effective for one direction of wheel rotation only and, therefore, the brakes are not interchangeable between the right and left wheels of an airplane. The brakes are marked with the direction of rotation of the wheels with which they are designed to be used. The marking indicates the direction of rotation as viewed from the wheel side of the brake.

Duo servo brakes are effective for either direction of wheel rotation. They are interchangeable between the left and right wheels of an airplane, and are effective for both forward and backward motion of the aircraft.

Single servo brakes have only one piston in the actuating cylinder. This piston acts to expand one end of the brake shoe against the wheel drum.

The brake actuating cylinder on duo servo brakes has two pistons. Both ends of the brake shoe are expanded against the brake drum simultaneously.

You can operate both of these types either by mechanical or hydraulic means.

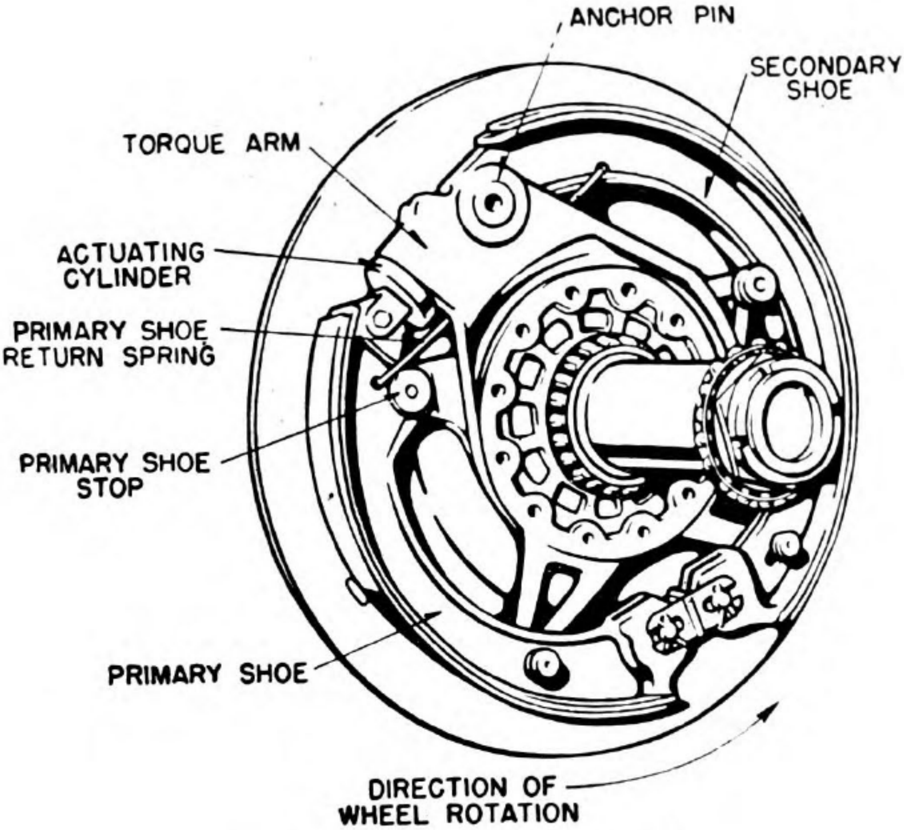


Figure 34.—Single servo brake assembly.

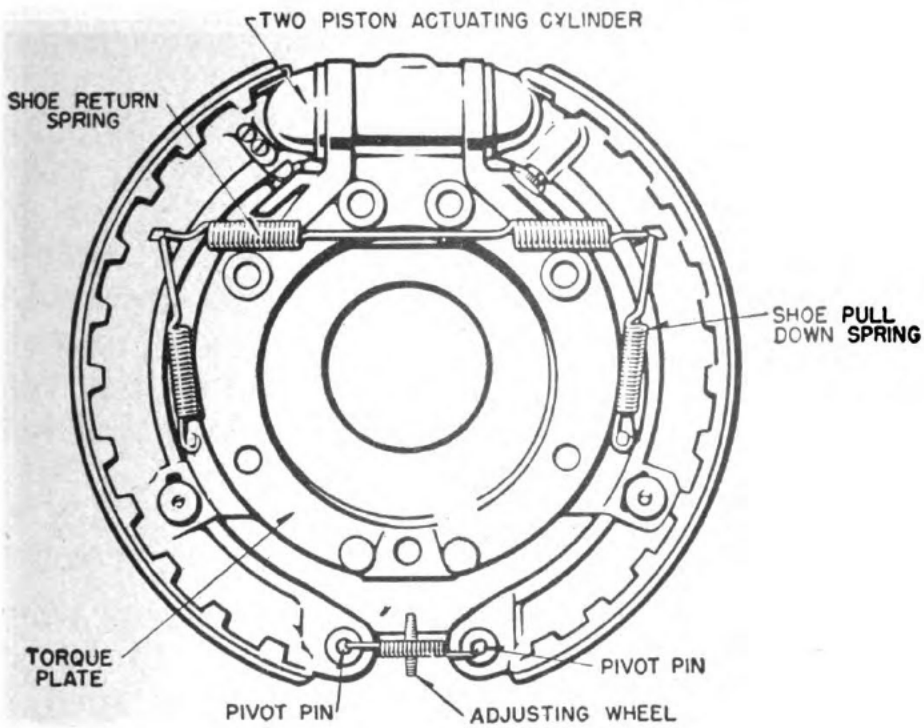


Figure 35.—Duo servo brake assembly.

Another type is called the expander tube brake. An inner shield fits between the flange on the axle and the brake frame. The brake expander is a hollow tube of rubber compound and fabric. It is stretched over the brake frame between the side flanges.

The expander tube brake is operated by fluid pressure and may be used with any of the conventional hydraulic brake systems. When the pilot applies the brake pedal, the pressure sends fluid into the expander tube. This tube is restrained from moving inward or to the sides. The fluid in the tube, therefore, forces it to expand outward and presses the brake blocks against the brake drum.

RETRACTABLE LANDING GEARS

Because most airplanes are so different in size, shape, and construction, almost every retractable landing gear is of special design. Some fold backwards into the wing, some sideways into the wing, some into the fuselage, and some fold in other ways.

You'll find landing gears operated by cable and levers, by long jack screws, or by worm gears. They may be mechanically, electrically, or hydraulically operated. Usually there is a warning indicator on the instrument board to show when the wheels are down and when they are up, or if they are stuck part way. Hydraulically and electrically operated gears are also provided with mechanical operation for emergencies.

SKIS

Skis are used on airplanes only in areas where the deep snow or ice make it impossible to operate with wheels alone. If you're ever in such an area, you may find several types of landing ski

arrangement. One of the most convenient types is pictured in figure 36.

This type of ski is designed with an opening through which the wheel protrudes. It is attached to the landing gear on each side of the wheel. Such a ski is an all metal structure. Obviously, skis cannot be fitted to airplanes with retractable landing gears unless the landing gears are left in the extended position, or the skis can be dropped after take-off.

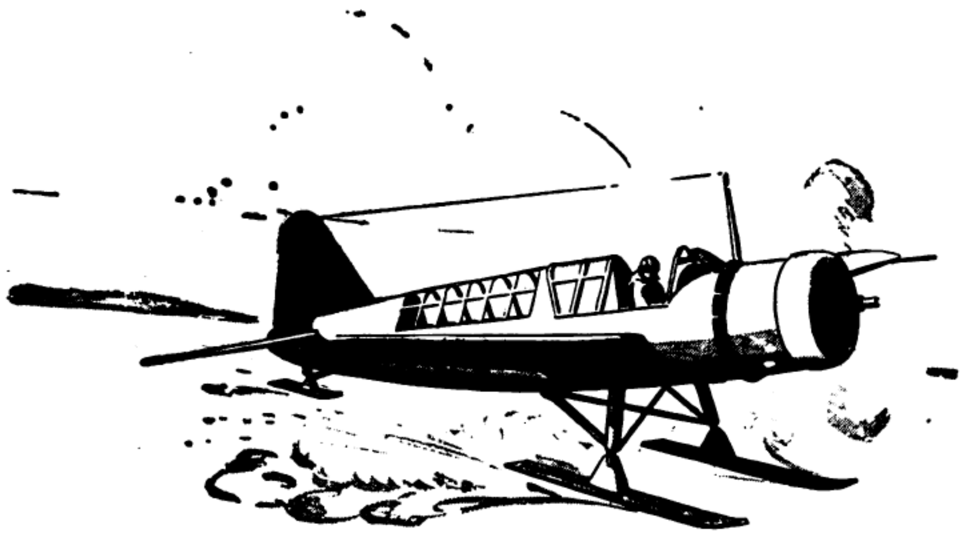


Figure 36.—Airplane equipped with skis.

FLOATS AND HULLS

When you speak of airplanes which can land on or take off from the water, you should distinguish those with floats and hulls. Those equipped with floats are generally called seaplanes and those with hulls, flying boats or just boats.

An airplane with one main float is called a SINGLE FLOAT seaplane. This type also has small floats at each wing tip to prevent capsizing. If the airplane is equipped with two large floats which share equally in its support, it is known as a TWIN-FLOAT seaplane. Twin-float seaplanes

don't need wing tip floats. The horizontal distance between the centers of the floats is called the tread. Sometimes these floats are braced by a bar running from one to the other. This bar, called a SPREADER BAR, is pictured in figure 37.

The covering of the float is known as the skin and in modern seaplanes is usually made of aluminum alloy sheet. Alclad is preferred because of its greater corrosion resistance. The rear part of the float is called the stern, the front is called the bow. You'll find that the nose of most floats is provided with a bumper. This prevents damage to the nose when the float strikes a dock or some other solid object. The rubber bumper is usually covered with canvas and stretched taut.

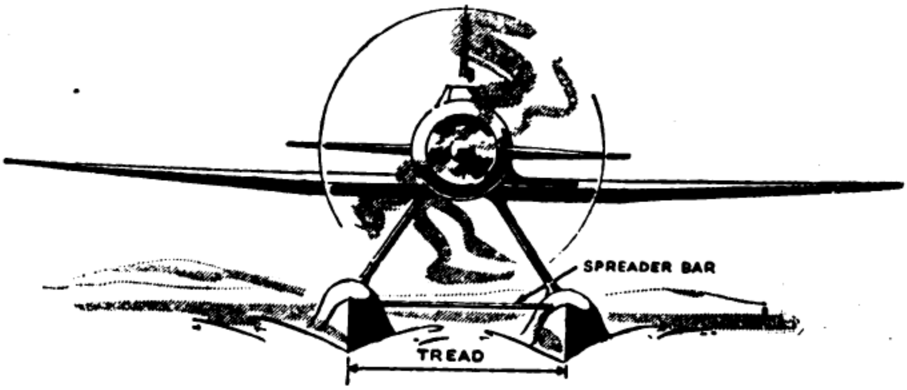


Figure 37.—Twin float seaplane with spreader bar.

The top of the float is known as the deck, and the stringer (running lengthwise) which attaches the deck to the sides, is called a deck clamp. The curved members, which give the float its shape in cross section, are known as FRAMES. The structural members running lengthwise (stringers) are attached to the frames. If these frames are made so that water cannot pass through them, they are called transverse watertight bulkheads.

In the deck there are hand holes which have removable sections. You'll be using these for

inspection, for pumping out water, and for access to the inside of the float to make minor repairs. Now look over figure 38, which shows you just where the various parts are located.

There is usually a handhole for each WATERTIGHT COMPARTMENT. WATERTIGHT bulkheads, attached to the skin, separate the float into four or more watertight sections. Consequently, you see, a leak will allow water to enter only one relatively small portion of the float.

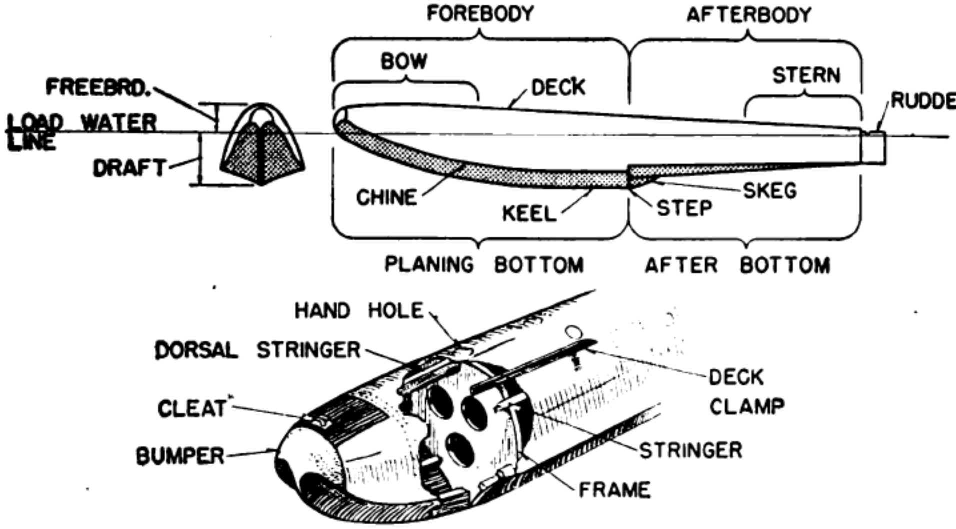


Figure 38.—Float construction.

Most floats are equipped with a RUDDER. This is attached to the stern post and is used for steering the airplane on the water. The bottom of the float has a "jog" or step about halfway between the bow and the stern and extending all the way across the bottom of the float. This step breaks the suction between the bottom of the float and the water and makes it easier for the airplane to take off.

The KEEL, like that on a ship, is the lengthwise member in the center of the bottom. It is really a spar made of rather heavy metal to which the two halves of the bottom are riveted. Usually, too, you'll find a strip of metal attached to the

outside of the keel. This extra piece is known as the RUBBING STRIP. You can remove it from the outside of the float when it is worn and replace it with another. KEELSONS, also called bottom stringers, run parallel to the keel on both sides. With the keel, they form the frame of the bottom.

You'll find some seaplanes provided with fittings, fastened to structural members inside of the float but projecting outside the skin. Wheels and struts, known as the BEACHING GEAR, may be attached to these fittings. Such a beaching gear is used instead of an axle arrangement and is superior to it.

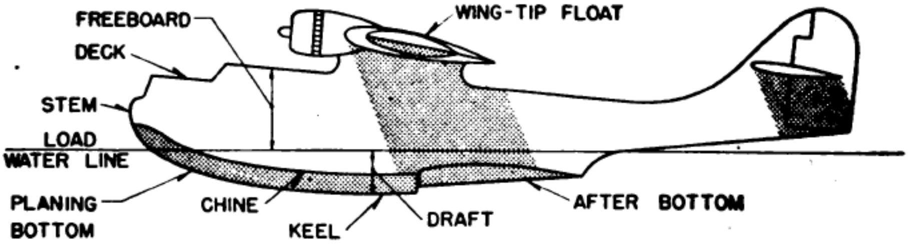


Figure 39.—Hull of flying boat.

HULLS

The hull of a fiying boat is actually a combination float and fuselage as you can see in figure 39. The hull is the main body of a flying boat and carries the crew, passengers, equipment, and cargo as does the fuselage of an ordinary airplane. Unlike the fuselage, however, the hull has a keel, similar in many ways to that of a motorboat. This keel is built so as to present the greatest internal strength and the least external resistance to water, rather than air, and comprises the lower part of the hull. The upper part is built much like an ordinary monocoque fuselage.

However, as was mentioned before, the keel of a flying boat differs from that of an ordinary boat as it has one or more steps. These steps break the water on the keel when the flying boat is taking

off. When a step includes an air hole to prevent the formation of a vacuum between the keel and the water, it is said to be "ventilated." Such steps are sometimes used on large, multi-engine flying boats.

The general construction of a flying boat hull is similar to that of a float. Both girder and monocoque construction may be used but semi-monocoque design is usual. The hull is divided into compartments by transverse bulkheads. The crew members have to move back and forth through the hull. Consequently, the bulkheads are provided with watertight doors which may be closed in case of damage to some portion of the hull.

Flying boats are also provided with a bumper at the extreme nose and with either wing-tip floats or sea wings to keep them from capsizing. Some hulls are provided with additional flotation by extending the bottom out beyond the sides. The extension runs diagonally back to the side and is known as a SPONSON.

The amphibian airplane, which is capable of landing on either water or land, may include either a hull or floats along with a retractable landing gear. You'll probably run into some real problems in connection with amphibians because such structures are conducive to leaks. Moreover, the landing gear materials are exposed to salt water which results in corrosion.

CHAPTER 8

FABRIC, METAL AND PLASTIC REPAIR

A STITCH IN TIME

You're well aware by now that Navy airplanes are metal-covered for the most part. But you also know that the control surfaces, even on speedy fighters, are often fabric-covered. And, of course, many trainers have fabric-covered wings.

You don't need to concern yourself, however, with the procedure for completely covering wing panels with fabric but you ought to be able to cover a rudder, elevator or aileron. And particularly, you should know how to patch small holes, and to repair punctures and tears in fabric.

Fabric-covered surfaces, you realize, must stand up under the strains of varied forces. For instance, think of the forces which act on a fabric-covered airfoil in speedy flight. There is a lowered pressure on the upper surface of an airfoil when an airplane is in flight. This means that

the greater pressure below pushes upward and gives the airfoil lift.

What would happen to insecurely attached fabric on an airfoil?

The force on the upper camber of the airfoil woud rip the fabric away from the ribs.

When fabric is applied to an airfoil, it is attached to the ribs by a process called stringing. You probably will not be stringing the fabric on wing panels but you will be covering and stringing fabric on the various control surfaces, so you should understand the process involved.

Before you do any covering and stringing, however, make sure you check the part you're going to cover for structural strength and security of enclosed equipment. Never cover a part which may have a weakness or for any reason is likely to fail.

Here's the procedure for covering a surface whether it be a wing panel or a control surface—

First, you have your choice of either the envelope or blanket method. The ENVELOPE METHOD involves sewing together widths of fabric cut to specific dimensions and machine-sewed to form an envelope of fabric. Then you draw the envelope over the frame of the surface you're covering. The trailing and outer edges of the covering should be machine-sewed. If the frame is not favorably shaped for such sewing, you should sew it by hand.

The other method is called the BLANKET METHOD. It is accomplished by sewing together widths of fabric of sufficient lengths to form a blanket-like covering for all surfaces of the frame. You should join the trailing and outer edges of the covering by using the baseball stitch.

In both types you should cut the fabrics in lengths large enough to pass completely around

the frame, starting and ending at the trailing edge. The only seam along the span should be at the trailing edge, except in the case of a tapered wing or surface. In that case, an additional seam may be made at the tapered portion of the wing at the leading edge. You should join the fabric by hand-sewing at the inner and outer ends of the frame, at recesses, hinges or other obstructions which make it impractical to draw a machine-sewed envelope over the frame.

In a lacing job (sometimes called rib stitching) you should use a large needle 8 to 15 inches long and about 6 feet of cord. First fasten reinforcing tape of the same length as the rib to the fabric and over the rib. Then start at the leading edge and pass cord completely around the rib, fabric and reinforcing tape. Insert the needle as close as practical to the rib and bring it back around the rib through the fabric equally close to the opposite side of the rib and directly opposite the first stitch.

Tie the ends of the cord with a square knot for the top camber and a square knot and two half

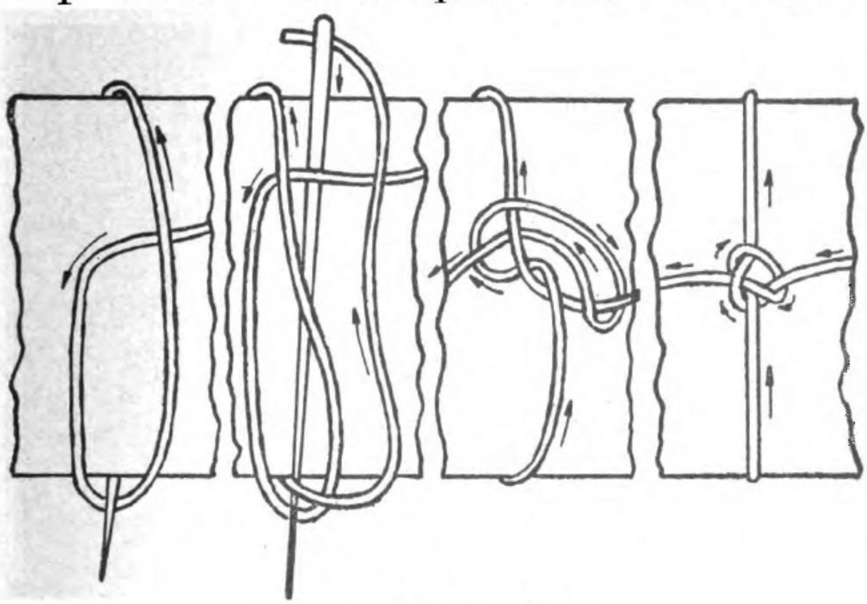


Figure 40.—Seine knot.

hitches for the bottom camber. The cord must be good and tight before it is carried to the next point. Now pass it through the fabric again, around the rib and out the other side. Tie it with a modified seine knot as shown in figure 40.

At the finish of the rib lacing, secure the cord by tacking or by a double or lock knot. Tacking consists of sewing for two or three stitches and then locking the thread.

DOPING

After a surface has been properly covered, reinforced and rib-stitched, brush clear dope on one side. Allow it to dry. Then turn the surface over and brush clear dope on the other side. Let that side dry.

Brush on the second coat of clear dope as the tape and accessories are applied—or immediately afterward. Apply the succeeding coats of dope with a spray gun. The gun should be adjusted to give a smooth fan-shaped spray. Hold the gun about 6 inches from the fabric. Move the gun continuously so as not to get too much dope on any one spot. If a run appears, don't try to wipe it off. Wiping will remove MORE than just the last coat of dope. Let the run dry. Then smooth it down with a light abrasive. Each "pair" of coats should be cross-sprayed. In other words, spray one coat using strokes in the long direction of the member and spray the second coat using strokes in the short direction of the member.

After the doping is completed, any required letters, numerals or insignia can be added by masking and spraying. If spray equipment is not available, the succeeding coats can be applied with a brush. In this case, not as many coats are needed. One brush coat is considered about the same as two spray coats.

Small holes in the various fabric-covered surfaces of an airplane may be caused by flying stones from the runways, careless handling in the hangar, or by bullets. But you'll find fabric repairs much easier to make than repairs in metal surfaces. It's important to make these repairs when the damage is first noted. By doing this you can avoid more serious repairs or perhaps even a complete new covering job.

Small punctures and tears in airplane fabric can be repaired simply by patching. There are no definite rules, and the decision is usually left up to you. However, the following types of patches are generally used to repair holes less than 2 inches across in any direction—

To repair a small hole, trim the edges of the damaged area so that no frayed or damaged fabric remains. For best results, trim the hole so that it is either square or round. Then remove the old dope from around the hole for a distance of about 3 inches. One of the best and easiest methods of removing this dope is to brush it with clear dope first. Let the clear dope soak into the fabric for a minute or two, until the old dope has been softened. Then scrape the original dope off the cover with a knife. Be careful not to use too much pressure, or the fabric will scratch and a neat patch will be impossible. If the fabric does scratch while scraping away the old dope, cut away the scratched fabric, even though it makes the hole larger.

Also BE SURE TO SCRAPE AWAY ALL THE PIGMENTED DOPE. You may find it necessary to soften and scrape the fabric several times. When all the pigmented dope has been removed, the area may be smoothed with abrasive. Smooth the cleaned area so that it fades into the rest of the surface. There

should not be any "bumps." Now the hole is ready to be patched.

Cut the fabric patch OF THE SAME MATERIAL AS THE ORIGINAL COVER. The patch should be big enough to extend AT LEAST $1\frac{1}{2}$ INCHES BEYOND THE SIDES OF THE HOLE. Pink the edges of the patch with pinking shears or a pinking machine to prevent raveling and to make the edges stick better. Pinked edges are scalloped with little indentations. The properly pinked patch should look like the one shown in figure 41. For a square patch, if neither a pinking machine nor pinking shears are available, the edge of the patch should be frayed for a distance of about $\frac{3}{16}$ of an inch. Fray the edges by pulling out the threads that run parallel to the edges.

Your next step is to brush a coat of clear dope over the cleaned area of the fabric. While the dope is still wet, rub the patch into place over the

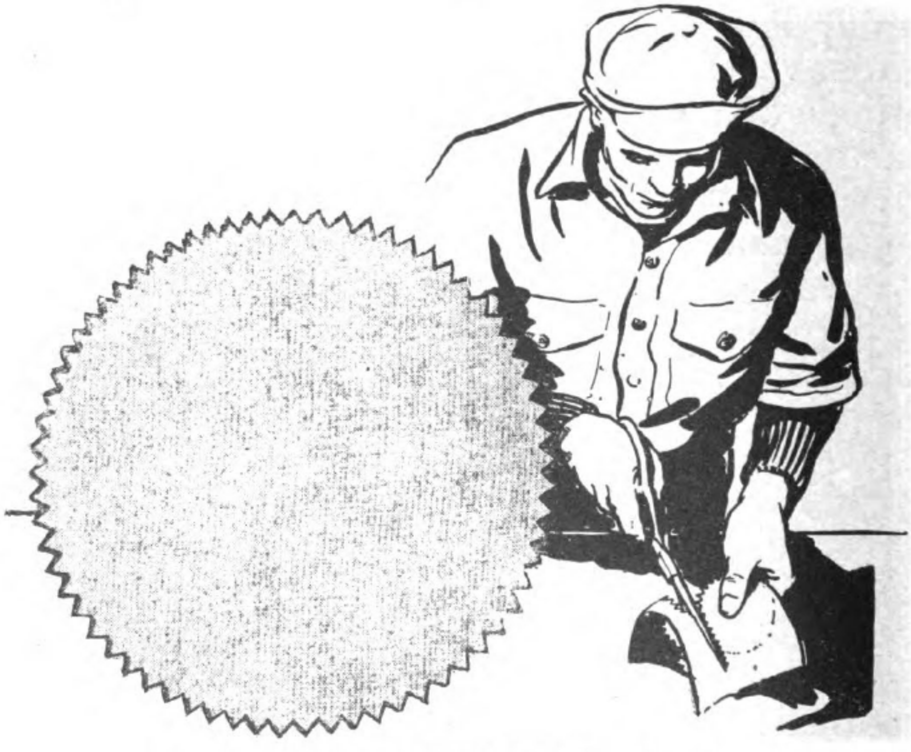


Figure 41.—Properly pinked patch.

hole. If the patch is square, its edges should line up with the ribs or slip stream for best appearance.

Now give the portions of the patch that extend over the sides of the hole a coat of clear dope. This should be done IMMEDIATELY after the patch has been rubbed into place. If dope gets on the center of the patch, it will cause shrinking which may pull the edges loose. Let the patch dry for 15 or 20 minutes. Then give the EDGES of the patch another coat of clear dope. After the edges of the patch are firmly stuck, you should build up the entire patch and the cleaned area to the original finish of the cover with the proper number of coats of clear dope and pigmented dope. Smooth off the various coats with abrasive. The patched fabric is then ready for service.

Such patches are meant to repair holes. BUT TEARS SHOULD BE SEWED before patching. First, clean the fabric of old dope. You can do this in the same way as you remove old dope for small patches. When the damaged area is in the form of an L, T, or X, the stitches should begin at the ends of the tear and move inward toward the intersection. Sew the tear so that it can be closed tightly without "bunching." Use a curved needle to make the standard baseball stitch when sewing the tear. Secure the last stitch with a knot. Cover the seams with wing tape. The job is finished the same way as with smaller holes.

When patching a large area which has been torn, trim the damaged area to a square or rectangular shape parallel to the ribs or to the slip stream. Remove the old dope from around the hole, the same as for patching a smaller hole. When the surface has been cleaned, make a 45° cut in each corner of the hole so that the edges can be turned under for a distance of one-half

of an inch. Then cut a patch of the same material as the original cover. This patch must be large enough so that, when its edges have been folded under one-half of an inch, it will JUST FILL the hole to be repaired. Pin the patch firmly in place over the hole. Sew the patch in place with a curved needle, folding the edges underneath.

Be careful not to "bunch" the fabric at the seam. If the fabric should bunch, fold the excess material under the patch so that the seam will be flat. The patch should be free of wrinkles and taut when the sewing is finished. When the sewing is completed, cover the seams with wing tape. To insure a tighter seam, give the SEAMS and WING TAPE three coats of clear dope BEFORE doping the entire area.

To repair a damaged area where the fabric has been STRETCHED but is NOT broken, remove the dope from a good-sized section around the stretched fabric. Then soften the old dope with clear dope. Scrape it off with a knife. When the old dope has been removed, start with clear dope and build the finish back to its original thickness. Unless the fabric is too old, this treatment will shrink the fabric taut and repair the damage. If the stretched fabric will not shrink taut when new dope is applied, the wing or surface probably needs re-covering with new fabric.

REPAIRING METAL SURFACES

Cracks in engine cowling, wing tips, fairing surfaces and other nonstressed sheets are usually caused by vibration and buffeting of the air stream or by careless handling. As the strength of these parts does not affect the safety of the airplane, you can stop the crack by drilling a small hole, one-eighth of an inch in diameter, at each end of the crack. Then cover the damaged

portion with a patch shaped to fit the surface as shown in figure 42.

Here's the way to do it—

Drill a one-eighth of an inch hole at each end of the crack. This distributes the stress over a larger area and prevents continuation or spreading of the crack. Cut a piece of material of the same type and thickness as the damaged material. It should be large enough to extend well beyond the crack on all sides.

Form the patch to conform to the contour of the part and drill rivet holes in each corner. Hold the patch in place and drill through corner holes into the material being patched. Secure patch in place with screws of the proper size through the corner holes and lay out and drill other holes as shown in figure 42.

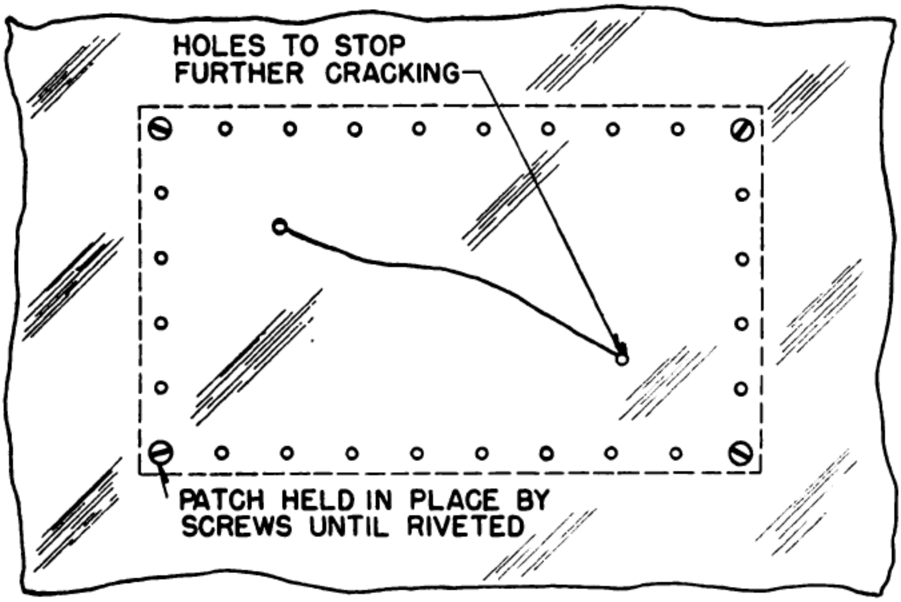


Figure 42.—Repairing crack in nonstressed skin or cowling.

Remove patch and clean off all burrs and chips. Then replace the patch, insert rivets with the head out. Head them on the inside.

Finally remove screws from corner holes and replace with rivets.

You can repair cracks in the skin cover of a wing, fuselage, fin, stabilizer, or control surface in much the same manner. Of course, a larger patch and a greater number of rivets will be required.

You can hammer out a dent in metal skin by using a hand dolly. A dolly, you know, is a heavy bar with a cupped head which you can hold behind the dent. Be careful, though, not to reduce the thickness of the metal. One other warning—don't use abrasive wheels or emery cloth to smooth up the surface.

If a covering skin has holes in it and if the holes are LESS THAN ONE-FOURTH INCH IN DIAMETER and are not too close together, you can repair them by smoothing out their edges and inserting a rivet. If the holes are larger, you should reinforce the area with a patch of the same material and thickness as the skin. But first you should file out all cracks existing around the periphery (edges) of the holes. The patch should extend 1½ inches beyond the sides of the hole and should be secured in place by two rows of rivets, one row three-eighths of an inch from the edge of the patch and the other three-eighths of an inch from the edge of the hole, using 3/32-inch rivets. Install the rivets from five-eighths to seven-eighths of an inch apart. You should apply a similar patch for abraded (worn by friction) sections.

If there's a large hole in the skin, you ought to replace the entire section in most cases. Here's how.

Cut the damaged section away using the inside boundary of stringers and bulkheads as a guide. Cut a replacement section from material of the same type and thickness but

allow 1 inch extra width on all edges from the joint.

Remove the rivets from the boundary of the cut-out and, holding the new section tightly in place, mark rivet holes from the inside. Drill rivet holes at points marked on the patch and secure it in place with rivets. Drill holes for another row of rivets, three-eighths of an inch from the edge of the patch and staggered between the rivets already in place. Then install rivets in these holes.

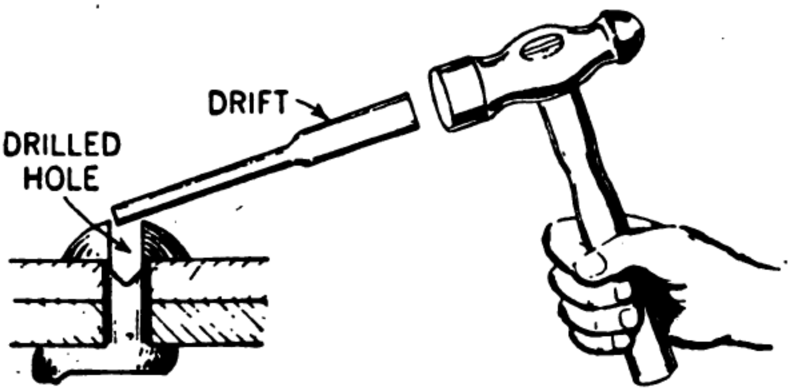


Figure 43.—Removing a rivet.

If you have to remove rivets in order to make repairs, use the following procedure.

First, center-punch the rivet head as shown in figure 43. The punch makes a slight indentation in the head. This indentation then serves as a guide for the drill. Next drill a hole in the head slightly smaller than the size of the rivet shank. Be sure NOT to drill as far as the sheet metal because your drill may not be exactly centered with the rivet shank. Moreover, rivet holes in sheet metal sometimes are lengthened out so that the shank is not perpendicular to the sheet of metal covering.

After the rivet head is weakened by drilling, you can knock off the head with a small

but sharp cold chisel. A single smart blow will do the trick. After the head is knocked off, you can push out the shank with a punch of smaller diameter than the hole.

REPAIRING TRANSPARENT PLASTICS

Plexiglas has greater transparency than other plastics, is strong and hard, and burns slowly giving off an acrid odor. It's used, you know, for bombardier compartments, gun turrets and windshields.

Don't disregard slight scratches on Plexiglas. On the contrary, buff and polish any scratched surface. You can remove minor scratches by vigorously rubbing the affected area by hand with a soft, clean cloth moistened with a mixture of turpentine and chalk or an automobile cleanser such as Johnson's "Carnu." Then remove the cleanser and polish with a soft dry cloth.

Remember, though, that Plexiglas is a thermoplastic. That means too much buffing or polishing can generate enough heat to soften the surface and this might produce visual distortion.

If the scratches are deep, you may find it necessary to sand the area around them. Don't confine the sanding to too small an area, however, or you'll get a bull's eye distortion. You can use turpentine and chalk and a buffing wheel to apply the final polish. Afterward clean the area and apply a coat of wax.

At the first sign of a crack developing in a Plexiglas surface, drill a hole one-eighth to three-sixteenths of an inch in diameter at the extreme end of the crack. Just as in the case of a metal surface, this operation localizes the crack and prevents further splitting by distributing the strain over a larger area. Stopping the crack with a drilled hole will usually do until you can

make a more permanent repair or replace the section.

Another good way to relieve strain which might lead to further damage is to LACE CRACKS. To do this, you drill a series of holes at intervals of 1 inch along each side of the crack, and about ½ inch from it. You can stagger the holes on opposite sides and lace them diagonally. Or you can drill them opposite each other and lace them as you do your shoes. Strong, flexible wire—such as copper or brass safety wire—is best.

The first step in repairing holes in transparent plastic panels is to trim the hole and surrounding cracks to a circular shape, if practical. This localizes the damage. Then cut a wedge-shaped piece of the plastic to the required size. Taper the edge so that it will conform to the taper of the edge of the hole being repaired. Make sure that the patch extends at least ¾ of an inch on each side of the crack or hole as shown in figure 44 and that the center of the patch is equal in thickness to the piece being repaired. You can fit a patch to a curved contour by heating it in an oil

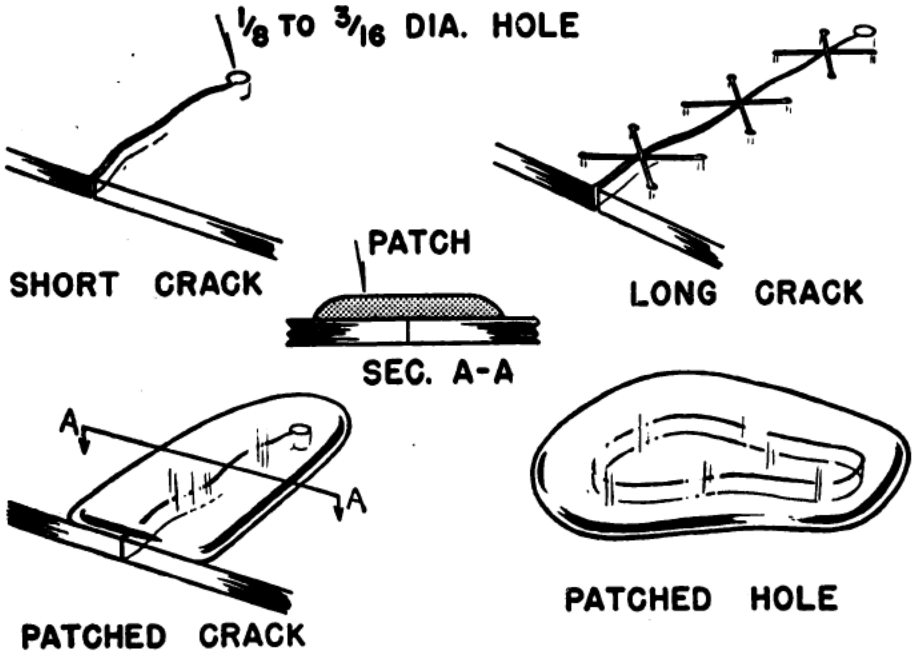


Figure 44.—Temporary patches.

bath at a temperature of from 121° to 149° C., (248° to 302° F.) or on a hot plate until soft.

Before you place the patch over the hole, attach masking tape (Scotch tape is OK) around the repair edge. Its edge should not be more than 1/16 of an inch from the edge of the patch. This taping is necessary because dichloride solvent paste will attack exposed plastic surfaces.

After the tape is in place, apply the plastic solvent paste evenly to the contact surface of the patch immediately over the hole. Use enough pressure to secure a thin even film of paste and to eliminate trapped air bubbles. Maintain a pressure of from 5 to 10 pounds per square inch on the patch for at least 3 hours, and don't do any polishing or sanding of the surface for 24 to 36 hours.

PLUG PATCHES

Another type of patch is called the PLUG PATCH. The hole must be trimmed to a circular or oval shape, and the edges shaped to a slight taper as

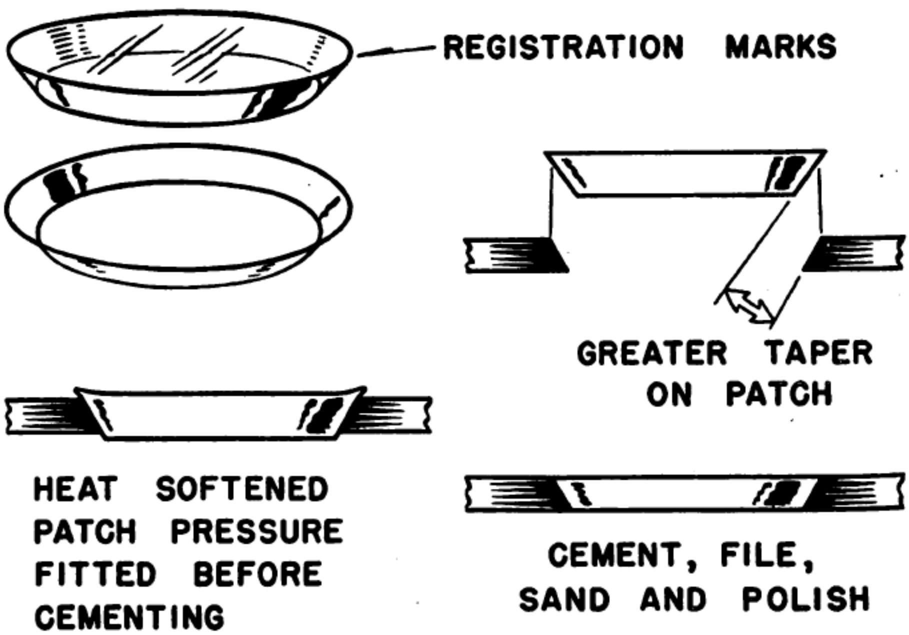


Figure 45.—Making a plug patch.

shown in figure 45. Cut the patch from a sheet of Plexiglas slightly thicker than the material you're repairing. Bevel the edges of the patch to the same taper as that of the hole. The edges of both the hole and the plug must be smooth. You can fit the plug to the hole contour by heating it until soft. Then seat the plug in the hole without bonding paste.

After the plug has cooled, while so seated, it should fit perfectly. Then remove the patching plug and spread dichloride solvent evenly along the tapered edge. Reinsert the plug in the hole and maintain a firm but light pressure until the bonding paste has thoroughly set.

EMERGENCY FORMING

If you are called on to form plexiglas into a curved section, you'll have to heat it—either in an oven or in an oil bath. The oven temperature range should be from 104° to 149° C., (220° to 300° F.). The boiling temperatures of such oil baths, from 121° to 149° C., (250° to 300° F.), are high enough and can be kept fairly constant.

Don't forget, though, that the heated plexiglas is extremely soft. Finger marks, glove marks, and particles of dust can make surface impressions. So guard against such imperfections which might later require considerable polish to remove.

Forms for molding this plastic may be made of plaster, wood, masonite, or plywood. In combat areas, where you may not have any forms available, you can do an emergency job by using the damaged section itself as a mold to construct the necessary form.

In the case of a badly cracked section, draw the crack together first by taping both surfaces. Make a wooden supporting structure which exactly fits the outside contour of the damaged section.

Then place the damaged section in the supporting structure, grease it and fill it with plaster of paris. When the plaster sets, remove it from the mold and carefully sand it to remove all imperfections—including, of course, the mark left by the cracks. You can now cover it with a soft cloth and you have a form like the one on which the original section was shaped.

To replace a plexiglas panel in the cockpit canopy, remove the screws and nuts which secure the assembly to the cowling. You can then lift off the bow and strips which hold the plexiglas panel in place. Disassemble the frame and replace the defective panel. If the rubber strips and the sponge rubber, located in the grooves of the frame, are in good condition, you can use them again. Apply a plastic caulking compound around the outside edges of the panel.

Although only the procedures for making plexiglas plastic repairs have been described, you can use similar methods for the repair of plastacele lucite and other thermoplastics.

CHAPTER 9

MAINTENANCE OF FLIGHT CONTROLS

FOR SAFE FLYING

When an engine conks in midair, you've still got a chance to bring the airplane down safely. But if there's even a minor difficulty in the control system, you'd better start thinking about your parachute—because you can't stay in the air long without control of the airplane.

The control of an airplane depends entirely upon a series of cables, pulleys, tubes, hinges, and other fittings connecting the control surfaces of the airplane with the cockpit. Obviously, it is highly important that this control system be inspected carefully at frequent intervals so that everything connected with it is kept in proper working order.

HOW WIRE CONTROLS WORK

You'll find steel wire cable used for most tail surface controls. This cable is highly flexible and

may vary from one-sixteenth to three-eighths of an inch in diameter, according to the load it has to carry.

Preformed steel cable is best. Preforming consists of giving each strand of wire the exact shape it will assume when it is twisted in the finished rope. One of the popular types is known as 7–19 cable shown in figure 46. The name comes from the fact that it is built up from 7 small strands of 19 wires each. Cables one-sixteenth and three-thirty-seconds of an inch in diameter are composed of 7 strands of 7 wires each. These wires are usually of stainless steel and are corrosion-resistant—but tinned carbon steel cable is used also.

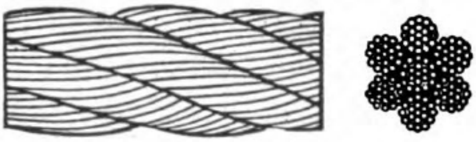


Figure 46.—*7 x 19 cable.*

You'll find several types of terminals used. Sometimes they are attached by an expanding screw device or clamp. They may also be looped around a thimble and spliced. Swaged terminals are generally considered simplest and best. In these the metal of the terminal shank is actually PRESSED INTO THE CABLE BETWEEN THE STRANDS. In some cable connections it's impossible to run a straight wire from one point to the other. The cable has to change direction to clear obstacles or to transmit pull at a different angle. Consequently, the cable must pass over either a pulley, or run through a fairlead, which is simply a supporting bracket for the cables. Take a look at figure 47 which shows control cable fairleads and pulleys. You can see from this diagram that fairleads are not suitable for sharp angles of change because of friction and wear. They are

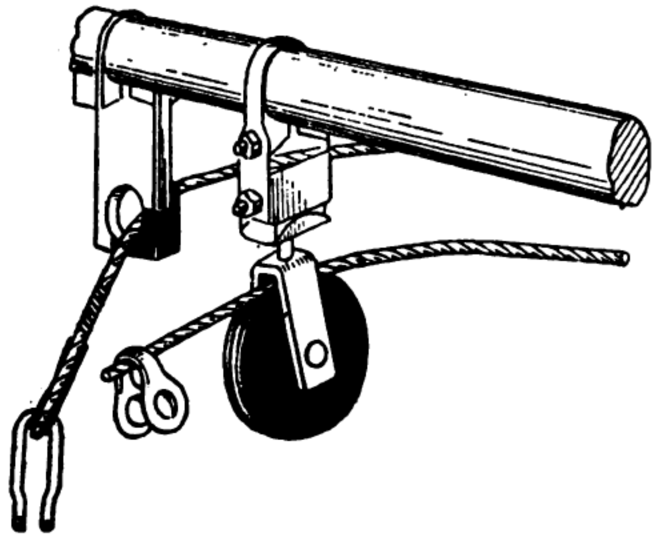


Figure 47.—Control cable fairleads and pulleys.

more useful for guiding wires that might sag from weight, and in protecting them from sharp edges and angles.

KEEPING WIRES TAUT

You'll find that aircraft cables will stretch with service and will require adjustment. One kind of stretch, called constructional stretch, is caused by the individual wires bedding down into one another the first few times a load is applied. Afterward, however, there is practically no stretch from this cause.

The other kind of stretch is known as elastic stretch. It's caused by cables being subjected to loads that actually stretch (or elongate) the individual wires. This type of stretch may increase up to the actual breaking point of the wire. Unless an excessive load is applied, the cable will ordinarily return to almost its original length when the load is removed.

Anyhow, when you find stretch in controls cables, there is only one thing to be done—and that is to shorten the wire. And you can easily do this since nearly every cable length is provided

with a turnbuckle. This device, as you know, consists of a threaded sleeve and two short threaded eye bolts. One bolt has a left hand thread, the other a right hand thread. If the bolts are held still and the sleeve turned in the proper direction, the bolt will be drawn together.

CABLE TERMINAL REPAIR

During inspection periods, or oftener if you can, test the control cables for broken wires by passing a cloth along the length of the cable. If the cloth is snagged, a wire is probably broken. Even if only one wire is broken, you should replace the cable. It's especially important to replace cables of the trim tab control system or of the main control system whenever breakages appear in a length of cable that normally passes over a pulley or through a fair-lead.

Wherever you can, you should replace a damaged cable with a spare that is an exact duplicate. If spare cables aren't available, you should prepare as exact a duplicate as possible. You'll find yourself in situations, however, where you've got to make a replacement without delay. In such cases, you can prepare a replacement by using thimbles, bushings, and turnbuckles in place of the original terminals. A thimble is a grooved ring of metal fitted within a spliced loop of cable. When such a replacement is made, you can weave-splice cables having a diameter of three-thirty-seconds of an inch or over by means of the 5-tuck method. And you can wrap-solder cables of less than three-thirty-seconds of an inch in diameter.

SWAGING

In a SWAGED TERMINAL, the metal of the shank has been pressed into the cable between the wires.

This process is carried out on a swaging machine which rapidly opens or closes two or more dies. Thus these dies hammer away at the terminal and cable inserted between them. The pressure—more than the blows—does the actual swaging.

When you're doing repair work, you should use a newly swaged terminal only where one was originally employed. Here's the way you swage a terminal.

> After you've prepared the necessary cable length with the allowance for fitting the necessary length under swaging, coat the end of the cable with lubricating oil. Insert the cable into the terminal about an inch. Bend the cable toward the terminal. Then straighten the cable back to normal position and push the end entirely into the terminal.
>
> Apply a drop of light oil to the terminal and insert it (the terminal) about one-fourth of an inch into the die while the die device is moving at a slow speed. Then insert the fitting entirely into the die and adjust it for regular speed. You'll get further instruction on swaging before you're called on to do an actual job, but this brief explanation should help you understand the process.

SWEAT-SOLDERING

You should use SWEAT-SOLDERED terminals in making up a new cable fitting only where they were used originally. You can use stearic acid and resin, or resin dissolved in alcohol as the soldering flux.

Here's the way to prepare the terminals—

> Apply the soldering flux to the end of the cable and insert the end of the cable into the

barrel of the terminal. Let the cable extend through the barrel a small amount. Free the end strands of the cable and allow them to fray. Pull the cable back into the barrel until it is flush. Then thoroughly sweat-solder (or melt the solder) into the cable and barrel until the solder appears at both ends of the barrel. Avoid overheating the solder.

You can always distinguish sweat-soldered terminals from swaged-type terminals by the airholes provided in the barrel of the terminal. These air-holes allow the molten solder to permeate or spread through the strands of the cable with no air bubbles present. Now take a look at some of the various types of cable terminals shown in figure 48.

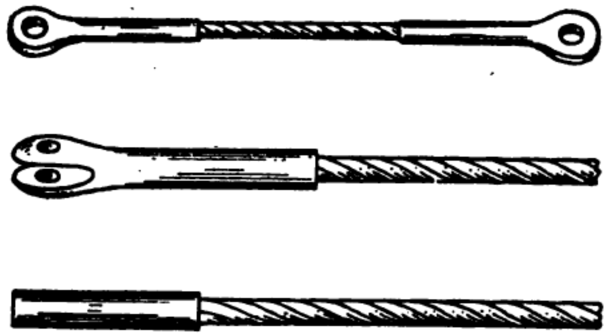


Figure 48.—Types of cable terminals.

CABLE-SPLICING

On cables three-thirty-seconds of an inch in diameter or greater, you can use five-tuck woven-spliced terminals in place of swaged terminals when facilities are limited and immediate replacement is necessary. In some cases you'll have to splice one end of the cable on assembly. So before you start, check up on pulleys and fairleads that might restrict the passage of the splice.

Look at figure 49 before you read the following paragraphs which explains the procedure in making a woven splice.

First, secure the cable around a bushing or thimble by means of a splicing clamp. Leave about 8 inches or more of the cable free. Secure the splicing clamp in a vise with the free end to the left of the standing wire and away from the operator.

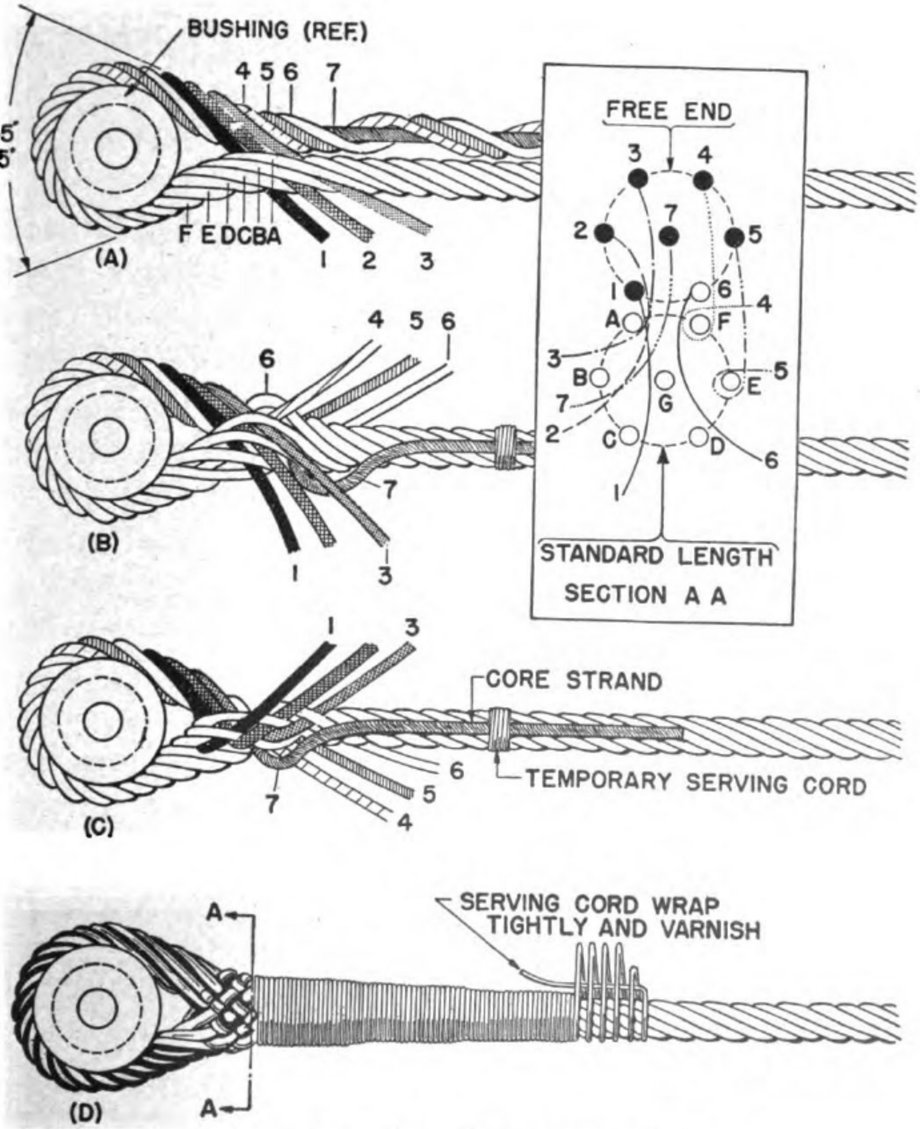


Figure 49.—Preparation of a woven cable splice.

Now refer to the diagram for the number and letter designations referred to in the next steps. Select the free strand (*1*) nearest the standing length at the end of the fitting and free this strand from the rest of the free ends. Next, insert a

marlinspike under the first three strands (*A, B, C*) of the standing length nearest the separated strand of the free end and separate them momentarily by twisting the marlinspike. Insert the free strand (*1*) under the three separated strands through the opening created by the marlinspike. Pull the free end taut by means of pliers.

Unlay a second strand (*2*) located to the left of the first strand tucked, and insert this second strand under the first two standing strands (*A, B*). Loosen the third free length strand (*3*) located to the left of the first two, and insert it under the first standing strand (*A*) of the original three as shown in the top diagram.

Remove the center or core strand (*7*) from the free end and insert it under the same standing strands (*A, B*). Temporarily secure the core strand to the body of the standing cable. (See second diagram.) Loosen the last free strand (*6*) located just to the right of the first (*1*) and tuck it under the last two strands (*E, F*) of the standing cable. Tuck the fifth free end (*5*) around the fifth standing strand (*E*). Tuck the fourth free end (*4*) around the sixth standing strand (*F*). (See details *B* and *E*.) Pull all strands snug toward the end fitting with the pliers. This completes the first tuck.

Begin with the first free strand (*1*) and work in a counterclockwise direction, tucking free strands under every other standing strand. After the completion of every tuck, pull the strands tight with pliers. Pull toward the end fitting. (See third diagram.) After the completion of the third complete tuck, cut in half the number of wires in each free strand. Make another complete tuck with the wires remaining. At the completion of the fourth tuck, again halve the number of wires in the free strands and make one

final tuck with the wires remaining. Cut off all protruding strands and pound the splice with a wooden or rawhide mallet to relieve the strains in the wires.

Serve (or wrap) the splice with waxed linen cord. Start one-fourth of an inch from the end of the splice and carry the wrapping over the loose end of the cord and along the tapered splice to a point between the second and third tucks. Insert the end of the cord back through the last five wrappings as shown in the bottom diagram. Then pull snug and cut off the end. If a thimble is used as an end fitting, bend down the points. Apply two coats of shellac to the cord. Carefully inspect the cable strands and splices for local failure. Weakness in a woven splice is indicated by separation of the strands of serving cord.

WRAP-SOLDERED SPLICE

If you want to make an end fitting on cables of one-sixteenth of an inch diameter, you can use the wrap-soldered splice shown in figure 50. Stearic acid, a suitable mixture of stearic acid and resin, or resin dissolved in alcohol may be used as the soldering flux. DON'T use hydrochloric (muriatic) acid as a flux.

Arrange the cable and the fittings as required, allowing approximately 2¼ inches of free end. Place the assembly in a splicing clamp and secure in a vise. Starting as close as practical to the end fittings, press the free end standing lengths of the cable together tightly, and wrap with a single layer of No. 20 brass or copper wire. Leave a space of approximately one-eighth of an inch between every half inch of wrapping. Be careful to prevent the standing length from twisting during this operation. Extend the wrapping about one-fourth of an inch beyond the free end.

Dip the wrapping in tin-lead solder and carefully sweat the solder into the cable and about the wrapping. Apply the solder until the wrapping wire can barely be seen. Make certain, too, that the open spaces between the wrapped sections are thoroughly filled with solder.

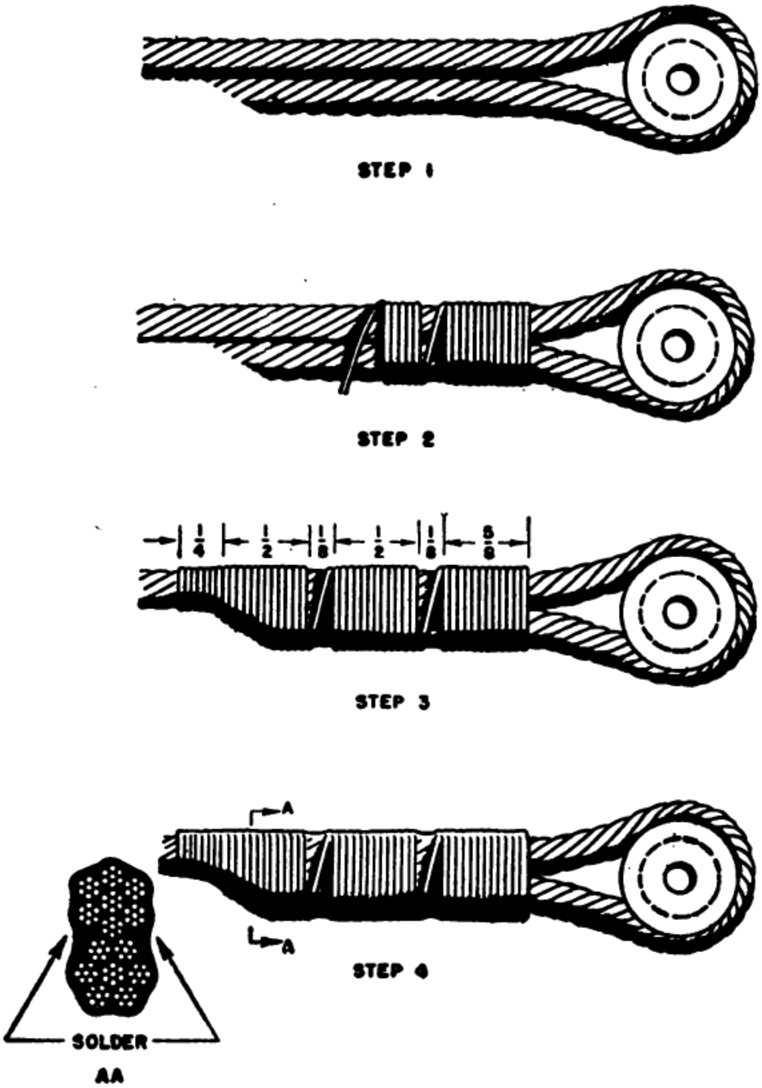


Figure 50.—Wrap-soldered splice.

After the splice has cooled, wipe it clean and remove all solder flux by washing in hot water. Wipe the cable and cover the spliced section with PARALKETONE or other approved corrosion preventative compound.

Finally, inspect your job carefully. A wrap-soldered splice, easily bent with the fingers, is unsatisfactory because the solder doesn't penetrate far enough. Cracks in the solder located between the wrapping wire and the short space provided between wraps is a positive indication of slippage in the wrap-soldered splice.

You should carefully test all cables and splices for proper strength before installing them. The best way to do this is to arrange the cables, including pulleys, in a set-up similar to their use on the airplane. Then gradually apply a load to one end of the cable for a period of 3 minutes. Place a suitable guard over the cable while it is being tested, to prevent it injuring you or anyone helping you in case of cable failure.

INSPECTION OF FLIGHT CONTROLS

You should inspect the flight control system daily. The most logical place to start inspection is in the cockpit since all controls are connected there. You can get at them by removing the cable guard at the base of the stick. Then, remove all panels which cover any part of the control system. Go over the full length of each cable with a cloth to see if any wires are broken.

Sometimes in checking the operation of a control, you may have reason to believe that an inaccessible part of the cable has been damaged. In such a case, check immediately with your crew chief. Under his supervision, the full length of the cable can be inspected by disconnecting it at one end and attaching a long cord to the connection and the end of the cable. You can then withdraw the cable, inspect it, and replace it without difficulty. The cord will guide it back to its original location—through pulleys and fair-leads.

When you inspect the cable for broken wires, you should also be on the lookout for signs of chafing. Track down any such trouble immediately and correct it. If rust or corrosion has set in on any part of the cable, replace the whole cable. Inspect the terminals at each cable. Check all fastenings for wear, tightness, and safetying. Cotter-pinned bolts, NOT clevis pins, should always be used. Also use only NEW COTTER PINS. Be sure that all shackles are snug, but that they can swing freely.

If there is too much slack in the control cable, take it up at the turnbuckle. In adjusting turnbuckles, use a small punch or still rod inserted in the hole in the barrel, and a wrench of the proper size on the threaded end. If the threaded end has an eye, use a rod through it. NEVER USE PLIERS ON TURNBUCKLES. Be sure each turnbuckle is properly safetied, and that no more than three threads are exposed at either end.

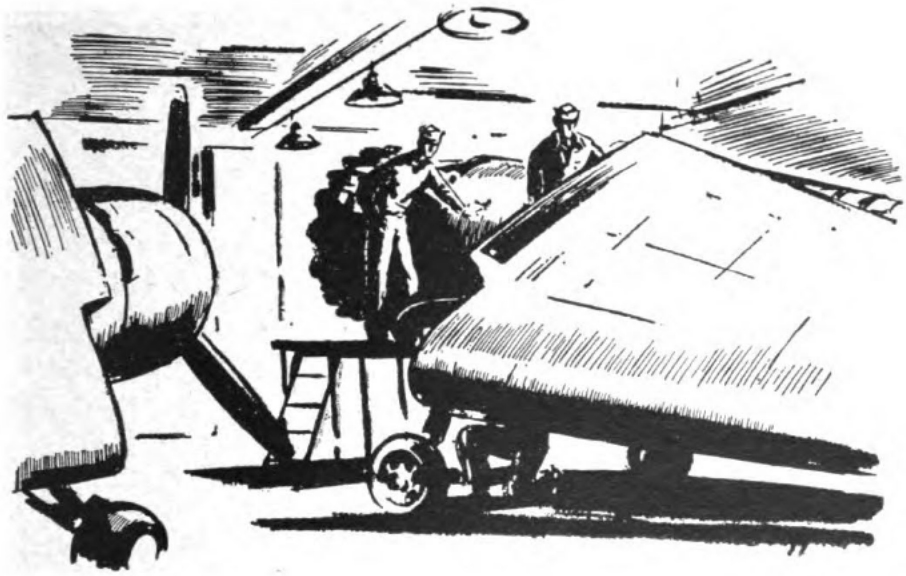
When you are satisfied that all control cables are in top-notch condition, give each one a light coat of PARALKETONE as protection against rust and corrosion. Don't grease control wires where they run over micarta pulleys or through micarta leads. Micarta is a special composition material used for pulleys, but grease makes it swell.

Pulleys, of course, should turn freely. Clean them thoroughly to remove all grease, dust, and dirt before attempting to examine them for wear. The guards should be spaced to permit easy operation of the pulley, and at the same time close enough to prevent the control cable from jumping the pulley. Watch out for cracks in the flanges, or broken corners. If there is any indication of weakness here, replace the pulley. Also, if the pulley shows any indication of jamming, it should be replaced with a new one. Otherwise, it should

be relubricated thoroughly and its fastenings secured.

Examine the fair-leads, or guides, to be sure they do not bind the control cables. Horns should be securely fastened to control surfaces. Check for cracks and bends. When in doubt—replace. IT'S BETTER TO BE SAFE THAN SORRY!

Examine the hinges connecting control surfaces. Hinges should operate freely, but should never be sloppy. Lubricate each hinge carefully, and be sure that all are properly safetied. Inspect the operation and condition of the rudder cables and connections. Make sure that when the rudder is in neutral position, the rudder pedals are even with each other. Tab-control connections must be inspected carefully to see that all fastenings are tight, and that they operate freely.



CHAPTER 10

MAJOR ASSEMBLIES AND DISASSEMBLIES

PUTTING THE PLANE TOGETHER

Someday you may be at a base where your airplanes don't fly in under their own power but, instead, arrive closely packed in the hold or tied on the deck of a merchant ship. If that's the case, you've got an assembly job on your hands. Of course, when an airplane comes in for a major overhaul, you'll have to disassemble and later reassemble all the major parts.

But whether you're on a Pacific island with only the minimum of equipment or at base, your assembly job is a vital one. Your assembly must hold together under the strain of combat.

The tools you'll need will vary with every job. However, always include an assortment of leather hammers, wrenches, screw drivers, drift punches, and a small pinch bar. You'll need additional equipment, depending on the nature of

the job. But some wooden horses, chafing gear, ladders, and an improvised wing bridle, a cable bridle, and a good strong block and tackle will handle the average job.

Place all tools and equipment where you can get at them easily at any time during the job. After disassembly and cleaning, it is good shop practice to inspect and replace in their fittings all fastenings, bolts, nuts, and clevis bolts on control surfaces. This will save sorting afterwards. If you find any that are the wrong size or defective, replace them at once. An assortment of tapered drifts for lining up bolt holes will come in handy. If these are not available, UNDERSIZED BOLTS will do in an emergency. Test all ladders, scaffolding, hoisting tackle, steel dollies, wooden horses, and blocking material you expect to use on the job.

Before starting any assembly, be sure the fuselage is securely braced and padded with suitable supports both fore and aft as shown in figure 51. In some cases, such as emergency field assemblies, these supports may be wooden-block staging or wooden horses. However, in ideal shop practice, specially built steel jacks are best.

If lifting points cannot be used or are not built into the fuselage make certain that the supports are well padded with chafing gear. Whenever more than one man is needed on the job, let each one know what he is to do and from whom to take directions.

LANDING GEAR

Now you are ready to begin the actual assembling. Usually it's safe practice to install the tail wheel first. Connect the two drag link fittings and the shock strut fitting. Be sure all castellated nuts are properly safetied. Connect, adjust, and safety the locking pin on the tail wheel lock, and fasten the eccentric pin which locates the tail

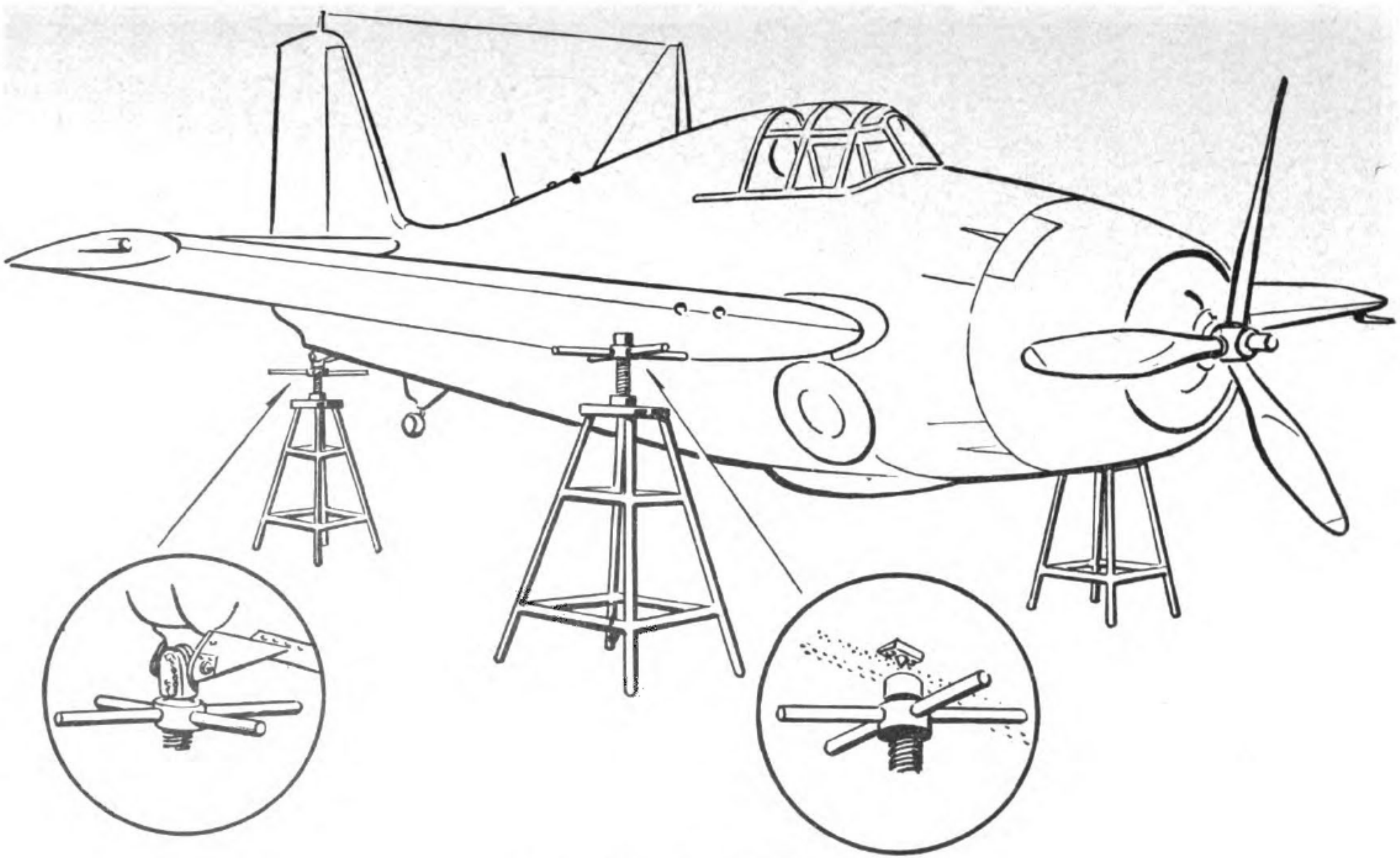


Figure 51.—Fuselage on jacks.

wheel in its fore-and-aft position. This completes the tail wheel assembly. The aft end of the fuselage with the attached tail wheel may now be removed from the dolley.

To assemble the main landing gear, raise the fuselage high enough so that the gear can be attached. The best way to do this is with a chain hoist. The chain hoist should be placed above the FRONT of the fuselage.

When you mount hoists on rafters or cross beams of the workshop, be sure they are strong enough to hold the hoists and the weight of the plane. A weak rafter can throw the plane into a nose dive which might do lots of damage—even though from only a few feet in height. If you are doubtful about any cross beam, reinforce it with temporary staging or props. The hoist should be attached to the beam or rafter with a strong chain or cable. If the chain has no hooks, fasten a clevis through the two end links.

If you do not have a chain or cable, attach the hoist to the beam with a stout line. Be sure the line is well-padded with chafing gear around all corners, so there is no chance for it to chafe. In tying the line, use only safe nonslipping knots, such as the reef and the bowline.

After attaching the hoist to the chain or line, "mouse" the hook. In other words, after the hook has been passed through the loop of the chain or rope, close the open throat of the hook by wrapping soft wire or twine around the tip and the shank as shown in figure 52. Then, lower the lifting hook of the hoist as close to the fuselage as possible. Attach this hook to the ship by a line or cable bridle.

In fastening the bridle to the fuselage, make sure you determine the location of the fastenings.

Figure 52.—"Moused" hook.

Station points on either the fuselage or the motor mount are always good ones from which to lift. If you use a cable bridle, the best point of attachment is usually at the motor mount stations. A bowline should be used, and care should be taken to loop the line around the station point at least twice to prevent slippage. Never attach a bridle between station points. "Mouse" the lifting hook of the hoist in the same way you did the other hoist hook.

You are now ready to hoist the fuselage. Raise the fuselage with the chain hoist, as smoothly as possible, until it clears its forward support completely. Now, slide the fore dolley clear of the fuselage. With one man at the chain hoist, an-

other at the shock strut, and the third man on the two lower brace struts, line the first half of the main landing gear in position. Line up the lower struts with the tapered drifts, and connect the struts to the fuselage. Raise the fuselage with the chain hoist until it is high enough to line up and connect the shock strut fittings.

Now attach the other half of the main landing gear, using the same procedure. Tighten all the strut fittings and safety them. If there are any bonding connections, secure them. If the airplane has hydraulic landing wheel brakes, you should secure the hydraulic lines at this point so as to eliminate the possibility of any dirt or dust getting into the system. If the landing gear is not of the fixed tripod type, but has adjustable brace wires, secure them. Of course, the procedure just outlined will vary with different airplanes, but it gives you a good general idea of the way you should handle the landing gear assembly.

WINGS AND TAIL GROUPS

It's impossible, of course, to give specific directions for all assembly jobs. Naturally the tools and procedure will vary according to the airplane model on which you're working. But here are some tips to remember when assembling wings—

First, always make sure that any hoisting setup you use will more than safely carry the load. Use the proper chafing gear and padded horses to avoid damage to the wing surfaces.

Be careful to secure and safety all fittings. It's a good idea also to secure landing connections during assembly.

Usually you should put the center wing section in place first. If it's a small airplane, you can have four men lift the center section and carry it

forward over the aft end of the fuselage to its proper position.

You can use a block and tackle arrangement for lifting the wing, but be certain it is properly secured to a suitable cross beam or rafter.

Attach the block and tackle to the padded wing bridle and carefully place the padded surface of the bridle under one of the outer ribs of the wing as shown in figure 53. Tie the block and tackle line slightly forward on the bridle.

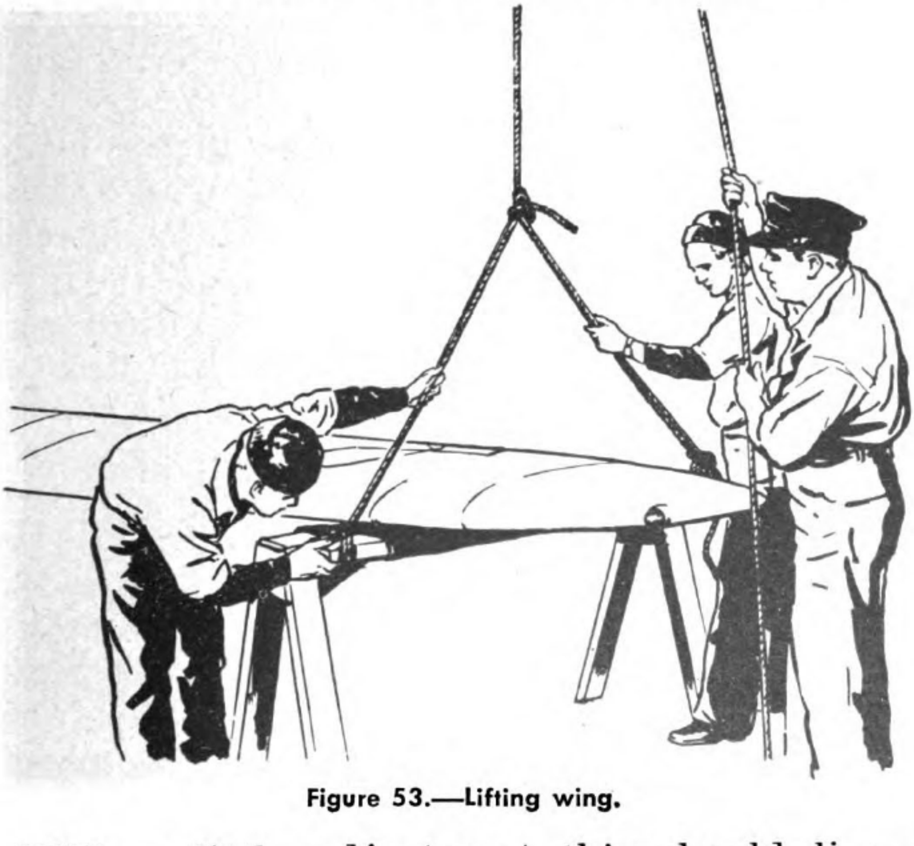


Figure 53.—Lifting wing.

With a little adjustment this should line up the wing with the tilt of the fuselage and make it easier to lift into position. With this set-up you can lift the wing with the block and tackle while your helpers guide the wing into its fittings. Line up bolt holes with a tapered drift and secure and safety the fittings.

On an airplane such as the Corsair fighter, you'll have to follow a far more involved pro-

cedure. The center section, however, is bolted, screwed, and riveted to the fuselage. The outer panels are attached to the center section at three points, the upper two points forming the hinge axis on which the outer panels fold. You have to assemble the outer panels before installing them. Follow the manufacturer's erection instructions for that procedure.

Then, with the airplane supported on the main wheels and a lift tube, lift the outer panel into position. Be careful, though, that the supporting is done against beams and not against the fabric between the trailing edge ribs.

When attaching the outer panel to the center section, be sure that the hydraulic wing-folding strut is fully compressed and that the connecting rod is completely within the outer panel. If you allow an outer panel to drop to the spread position with the unattached wing-folding link extended, you'll run the risk of damage to the outer panel.

Details of the step-by-step procedure in wing erection are not included here. You'll find such instructions in the erection and maintenance manual for the particular airplane you're working on. But the job will require a different approach on each type of airplane. Moreover, there are numerous connections which must be made—such as electrical conduits, surface control connections, airspeed lines, fuel lines, gun heater fixing, and others.

The final part of the airplane to be assembled is the TAIL group, or EMPENNAGE.

Line up the horizontal stabilizer on its station points on the aft end of the fuselage. Make sure that all its fittings and accessories have previously been installed. Install and safety all bolts and nuts on the horizontal stabilizer. Set the ad-

justable elevator tab control in the cockpit at neutral position. Then pass the adjustable elevator tab control cables through their fair-leads and safety the fair-leads as shown in figure 54. Connect the control cable terminals to the adjustable elevator tab roller chain drive. Attach the elevator control horn.

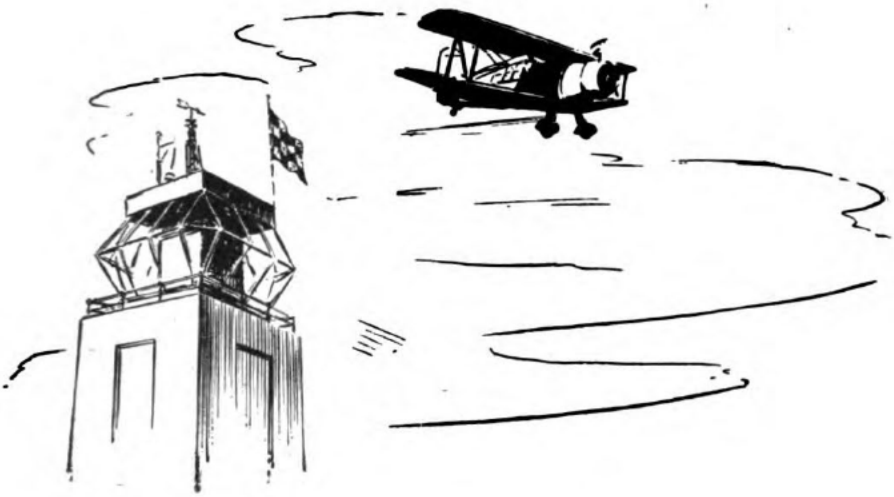
Now lift the vertical fin and slip it on the fixed slip-joint aft, and attach and safety the front attachment fittings. Secure and safety the brace wires or struts on the vertical fin and the horizontal stabilizer. Then attach and safety the elevators. Connect and safety the adjustable elevator tab control. Check and fasten any bonding connections. Attach the elevators to the elevator control horn and tube.

Next install the rudder. Safety all nuts and bolts and fasten any bonding connections. Now

Figure 54.—Safetying fair-leads.

connect the rudder cables. In some cases you'll find it necessary to install the tail fairing and fair-leads first before connecting the rudder cables. And as final step in the assembly of the empennage, secure the tail-light connection.

Your airplane is now completely assembled with the exception of the engine. It is good practice at this point to make a thorough recheck of the job against the manufacturer's specifications for any fittings, electrical or bonding connections, which may have been overlooked during assembly.



CHAPTER 11

RIGGING

MAKING THE FINE ADJUSTMENTS

The job of rigging an airplane is a lot simpler today than it used to be on box-like biplanes held together by countless wires and struts. You'll find that rigging now is primarily a matter of alining the structural units—wings, fuselage, landing gear, and tail group—according to the specifications for the particular airplane.

You aline these parts by lengthening or shortening the various struts and wires which hold them in place.

Don't confuse rigging with assembly. Assembly is putting sections together. RIGGING means alining them for flight. Although modern airplanes need much less rigging than older types, you should understand the basic ideas of rigging—so that you can check an airplane's alinement.

First of all, chock the wheels. Then before rigging any part of the airplane, place the fuselage

in "flying position"—that is, level, fore, aft, and laterally. Then anchor the tail so that the airplane can't move. This leveling process is easy if you know what parts of the airplane can be used as CHECKING POINTS.

For instance, if the top longeron of the fuselage is parallel to the line of flight, place the

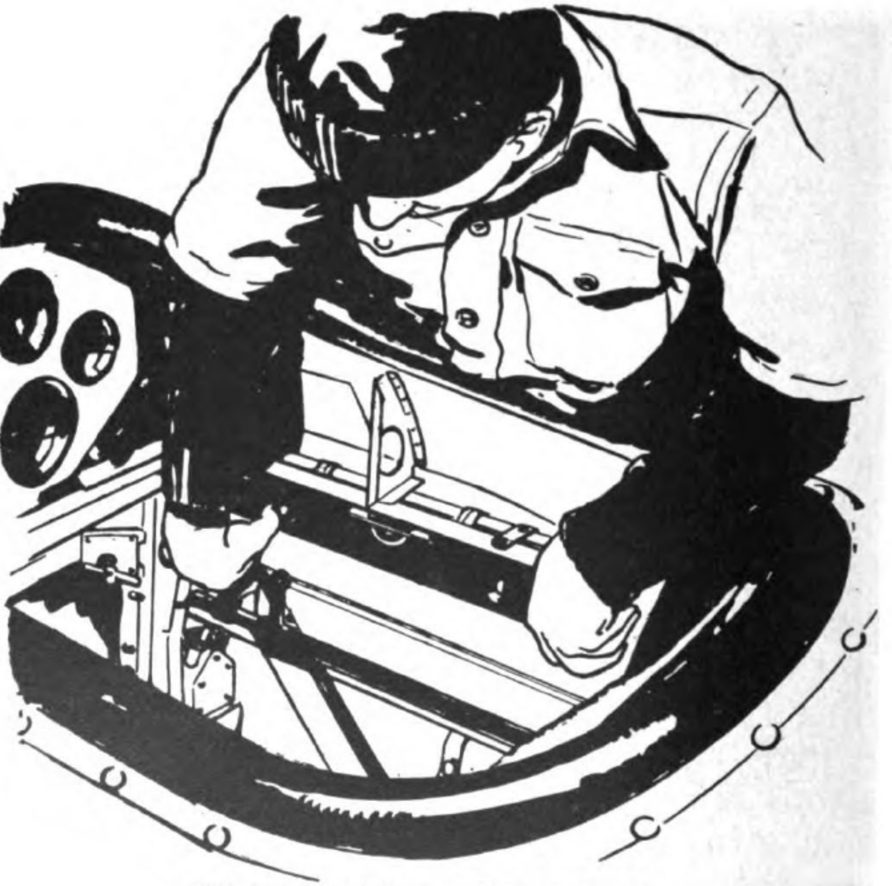


Figure 55.—Leveling of the fuselage.

spirit level on the longeron as shown in figure 55. Then raise the tail of the airplane until the bubble is centered in the level. The airplane will then be level lengthwise. Then place the level on a straight edge laid across the two top longerons. Jack up one side of the airplane or the other until the bubble is centered. Then the airplane will be level laterally.

Sometimes you'll find a particular place to put the spirit level when you are leveling the fuselage. In fact, most modern Navy airplanes are fitted with special points, such as short sections of tube or two plates welded to the fuselage. You'll find the type and position of these points described in the Erection and Maintenance Manual furnished as plane equipment.

Don't rely on ONE lengthwise reading and ONE crosswise reading to level the airplane. Take readings at several points. If NECESSARY, "split the difference." Never use nonstructural members—floor boards, seats, cowlings, window frames—for leveling. They may look level, but they will give inaccurate results.

Once the airplane is level, you can begin the actual work of checking alinement. Here is some of the equipment needed—several plumb bobs, some line, a steel tape, a trammel (a measuring device used in alining parts), a spirit level, and a level protractor. In checking fuselage alinement, you want to be sure that each part on one side of the fuselage is at the same distance from the centerline of the body as the identical part on the other side. This will tell you whether or not the body is twisted or out of line and whether or not the body has sagged.

One of the methods of alining the fuselage is to drop a plumb line from the center of the engine mount, from the rear hinge fittings of the wings, and from the top of the tail post. Then you stretch a horizontal line below the body so that it touches the string of the engine mount plumb line and that of the tail. If the fuselage is true, you'll find that the distance between that line and the plumb lines on each side of the wing struts will be equal. You can use the same check on other points on either side of the fuselage.

LANDING GEAR

Most modern wheel-type landing gears require no rigging. They are attached to the airplane by struts of exact length. This insures correct alinement when properly connected. You'll probably work on some airplanes, such as the N3N trainer which have landing gears that are braced by adjustable struts or tie rods. To rig this type of landing gear, you adjust each corresponding pair of struts or tie rods so that the trammeled distance from pin to pin is the same. You should check this distance, and also the tension, against the airplane's specifications.

Next turn to the center section. The first job is to center the center section over the center line of the fuselage. You can do this easily enough by checking the centers of the pins with the trammel. If you adjust wires, always remember to loosen one before you tighten the other. To check the adjustment with the rest of the body, you can drop plumb lines from the hinge fittings and make sure they're the same on each side. You should always check the tension of wires and cables with a tensionmeter.

WINGS

For purposes of illustration, suppose we take up the procedure of checking the wings of the N3N trainer.

On the N3N the top wing is one piece. There are no outer wing panels to consider. First, adjust the stagger, or the distance the upper wing extends ahead of the lower wing. On this airplane the stagger should be measured $26\frac{7}{32}$ inches from the centerline of the airplane.

Some airplanes have an adjustable stagger strut. To change the stagger, lengthen or shorten

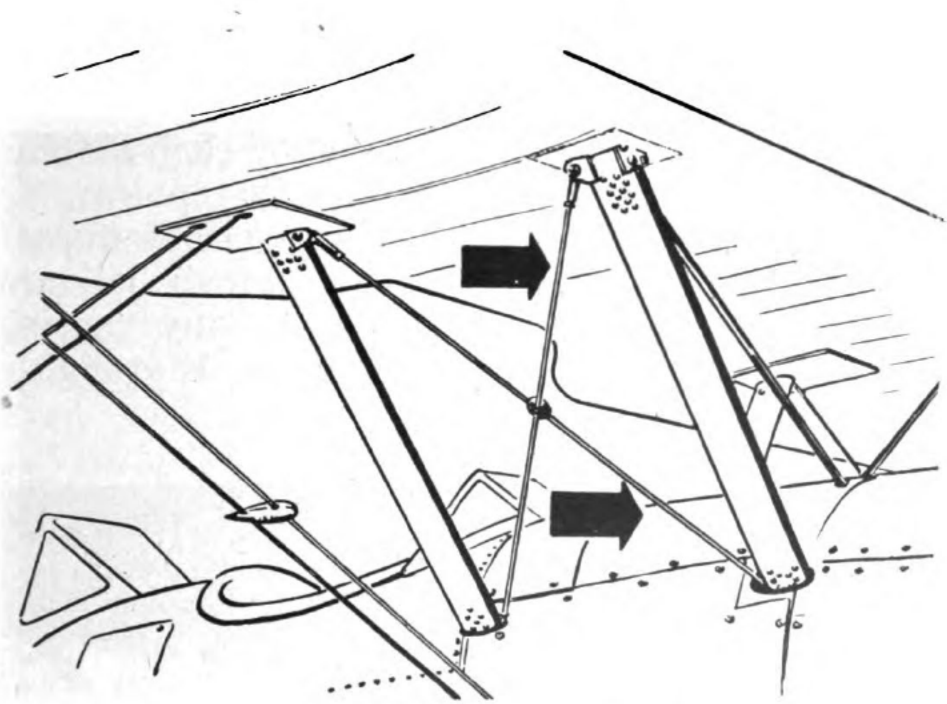


Figure 56.—Setting stagger.

this strut. You set stagger on the N3N–3 by proper adjustment of the cabane incidence wires as indicated in figure 56. Drop plumb lines from the leading edge of the top wing. Measure from them to the leading edge of the lower wing. When the distances are according to specifications the stagger is set.

Now level the upper wing. To do this, place a straightedge on top of the wing parallel to the front spar. Adjust and tighten the center section brace wires, sometimes called the rolling wires, until the bubble is centered. Then adjust the landing and flying wires until the upper wing is level throughout. Adjust the flying wires last. But don't draw the flying wires up so tight that they will bend the top wing out of line. Check the tension tolerances. If a gage is not available, only good judgment gained from long experience will make it possible to set the tension correctly.

Next streamline the landing and flying wires as shown in figure 57.

After the flying and landing wires are secured, insert a check wire in the pinhole of each tie rod to make sure the threads are past that point. If the check wire goes through, the tie rod is unsafe for flying. The rigging of the wings is now complete—but REMEMBER, no part of any rigging job is FINISHED until it has been thoroughly rechecked.

Figure 57.—Streamlining wires.

In the event the airplane you are working on has a tail group which requires rigging, recheck the lateral position of the plane to make sure it is still level. On the N3N–3 and on most modern airplanes, the vertical fin is not a separate unit but is an extension of the fuselage. Therefore, it cannot be rigged by the mechanic. However, its alinement can be checked by holding the plumb

level against the rear post of the fin. If the ship is laterally level, the fin should be exactly vertical.

Next, check the alinement of the horizontal stabilizers. Place a straightedge on the rear member of the stabilizer. Set a spirit level on the straightedge. If the stabilizers are correctly alined, they will be perfectly level. On some planes, the stabilizer struts can be adjusted. If you find that the stabilizers are NOT perfectly level, adjust the length of the stabilizer struts and recheck.

CONTROLS

You should adjust the rudder so that it is exactly parallel to the centerline of the airplane when the rudder pedals are held in the neutral position. Draw the rudder cables up to "rigger's tension"—that is, take in all slack—but not tight enough to BIND. Adjust the "travel" of the rudder by properly setting the rudder stop according to the specifications of the airplane. "Travel" is the maximum distance the rudder can move from right to left, and the maximum distance ailerons and elevators can move up and down.

You should rig the ELEVATORS so that they are perfectly in line with the stabilizers when the control stick is in a neutral position. Adjust the stops according to the specifications. Rig the AILERONS so that when the stick is held in neutral, the trailing edge of each aileron is in line with the trailing edge of the wing. Set the stops according to the specifications.

RIGGING CHANGES AFTER FLIGHT CHECK

Even though an airplane has been rigged correctly, it may develop certain faults while in flight or while taxiing. For this reason, it may be neces-

sary to make changes in the rigging after the airplane has been test-flown. These changes are made on the basis of the pilot's report as to how the airplane handled in flight.

One common fault which may show up during test flight is NOSE HEAVINESS—that is, the airplane constantly tends to nose down while in LEVEL flight. In most cases it is caused by wrong setting of the fixed insert elevator tab. A nose-heavy condition may also be caused by improper loading—too much weight forward.

To correct nose-heaviness, first check the alinement of the wings and fittings with the fuselage against the plane's specifications. If this is O. K., set the trailing edge of the fixed insert elevator tab down as shown in figure 58. But DON'T try to correct nose heaviness by putting a weight in the tail. If the weight distribution is wrong, move some of it back.

TAIL-HEAVINESS is a very dangerous condition, too. It tends to stall the airplane and cause a flat spin. Check thoroughly for the reasons before making any adjustment. Here are the three usual causes of tail heaviness—Too much weight, such as extra baggage or equipment near the tail of the airplane. Mud and debris in the tail-wheel opening. Or too much negative angle on the insert elevator tab.

Before trying to correct tail-heaviness, check to see that the original rigging has not been changed. If you notice any changes, correct them immediately. Then check the weight distribution. Do this by referring to the original drawing to see if any major parts have been added to, or removed from, the airplane. For instance, the airplane may have been designed for a 2-pound tail wheel, which was later replaced with a 10-pound tail wheel. If weight distribution and rigging

Figure 58.—Adjusting elevator tab.

specifications are found to be normal, decrease the negative angle on the insert elevator tab.

WING-HEAVINESS is usually due to PROPELLER TORQUE—that is, the tendency of the PLANE to rotate about the axis of its PROPELLER. When nothing is done to counteract this torque, one wing constantly tries to go down during flight. In other words, the airplane acts as though a weight were hung on one wing. The pilot must constantly hold this wing up with the aileron. Wing-heaviness can also be caused by a change of alinement after violent acrobatics.

To correct wing-heaviness, first check all wires and fittings to see if there has been any change in alinement. If so, make whatever adjustments are needed in the rigging. Wing-heaviness, as a

result of propeller torque, is corrected on most modern airplanes by proper adjustment on the insert aileron tab. Cantilever wings usually have a small metal tab which can be easily adjusted by bending either way. Proper adjustment will have to be checked by a test flight. Another method is to attach a small metal strip to the wing, as shown in figure 59. The strip should be about 12 x 4 inches, and the rear edge of the strip should be bent down about 30°.

A tendency of the airplane to swerve off its course while in straight line flight forces the pilot to carry enough rudder to counteract this tendency. This is usually caused by unequal drag on the wings. For instance, a washed-in (slightly warped) aileron tab creates more lift in the wing

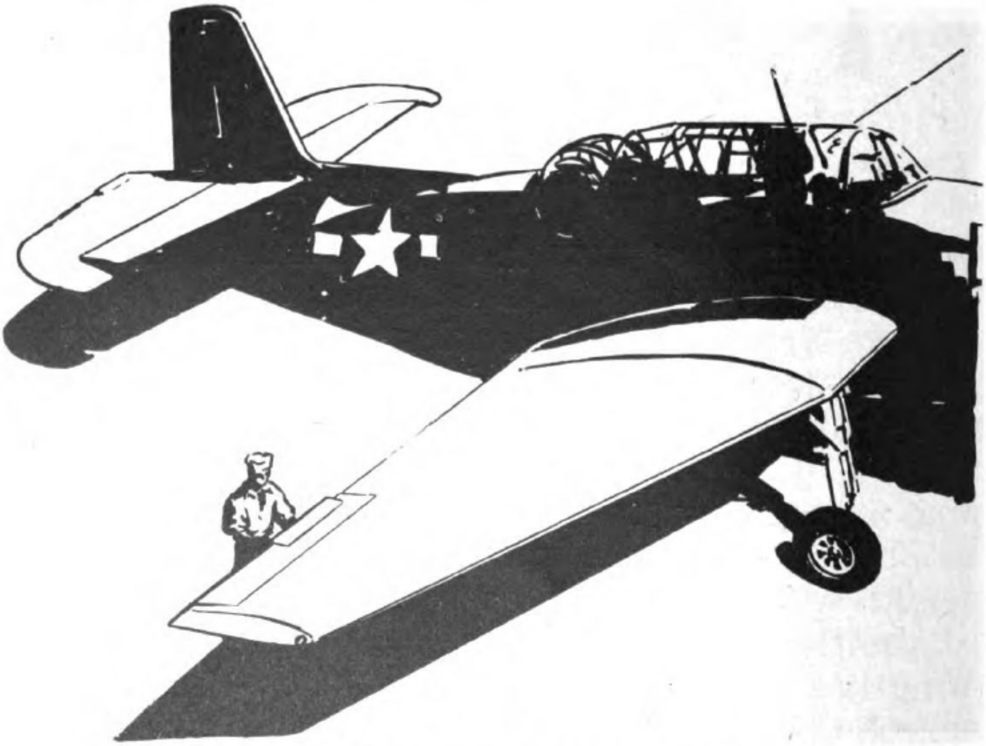


Figure 59.—Correcting wing heaviness.

and therefore more drag than a washed-out aileron tab.

This tendency of the airplane to swerve may also be caused by a misalined or damaged fuselage. If a careful check shows the fuselage to be correctly alined, however, "offset" the fixed tab on the rudder TO THE SIDE TOWARD WHICH THE SHIP TENDS TO TURN. When making such adjustments, change the setting of the tab only slightly. Then check the new setting by test flight. Otherwise, you may carry the change too far and simply reverse the action that you are trying to correct.

If the airplane has a tendency to wander back and forth (called yawing), it is probably because of misalinement of the fuselage, poor rigging of the wings, or some unusual loading condition. If yawing is due to misalinement of the fuselage, or if measurements taken at particular points do not check with the airplane's specifications, the airplane should be returned to the manufacturer or shipped to an authorized repair station for the necessary overhaul work.

Ground-looping is a tendency of the airplane to turn while on the ground—especially just after a landing. This may mean a broken wing tip or a damaged landing gear. Or it may mean a complete nose-over with disastrous results to both plane and pilot.

Sometimes ground-looping is the fault of the pilot and is caused by mishandling of the plane. For instance, applying the brakes carelessly, making a cross-wind landing, or landing with one wing low—any of these might mean a ground-loop. However, don't be too anxious to blame it on the pilot. Make a thorough check to see that the airplane is in proper condition. And here are

some faults in the airplane that can cause ground-looping—

Misalinement of landing gear.
Uneven adjustment of shock absorbers.
Improperly adjusted wheels.
Unequal air pressure of the brakes.
Damaged tail wheel and improper alinement of fuselage.

If any of these conditions ARE found, correct them at once.

CHAPTER 12

LANDING GEAR MAINTENANCE

BE SURE IT'S RIGHT

You've heard of airplanes that went over on their noses when the landing gear broke. You've heard of others with retractable landing gear that stuck in the retracted position—so that the pilot had to bring in the airplane on its belly. Perhaps you've even seen a faulty brake jam and spin an airplane upon a wing. Such landing gear or brake failures occasionally happen. But one of your jobs is to make certain that such accidents do not occur because you've neglected to make both a careful inspection and any necessary repairs of brake and landing gear mechanisms.

Of course, in wartime, machine gun bullets and antiaircraft fire can damage landing gear parts

so that they will fail. But that's something over which you have no control. You can, however, make sure that an airplane, which you have inspected and serviced never gets into the air until it is in safe condition for flight.

FIXED LANDING GEAR

Many Navy training airplanes have fixed landing gear. Suppose you check the principal points of service on this type of gear first.

At the time of a regular inspection you should go over every part of the gear carefully. Check the supporting struts for kinks, cracks, and other signs of weakness in the metal tubing. Examine the welded joints. Where there is any doubt of their strength, they should be checked for soundness by an experienced aircraft welder. Check all points where the landing gear is attached to the fuselage. Look for end play and looseness at the bolt holding the landing gear strut to the station point on the fuselage. Examine the castle (castellated) nut and cotter-pin for signs of wear and cutting.

The landing gear of most Navy airplanes, as you know, is equipped with a shock absorber strut known as the "oleo" strut. In this type of strut the landing shock is taken by the passage of oil through a small hole. A spring in the strut takes the shocks of taxiing. You should inspect this strut at intervals for leakage of oil past the packing rings. You can usually stop oil leakage by tightening the packing nut as shown in figure 60. If the leak continues, the packing is worn and should be replaced. Fill the cylinder with oil to the level of the filler plug—WHEN THERE IS NO LOAD ON THE AIRPLANE.

Another type of oleo strut has an air chamber, as well as the hydraulic mechanism. Such struts

should be checked for oil leakage the same as the others. In addition, watch for air leaks at the valve and filler plug. Air leakage is shown by bubbles in the oil that is smeared around the valve and filler plug fittings.

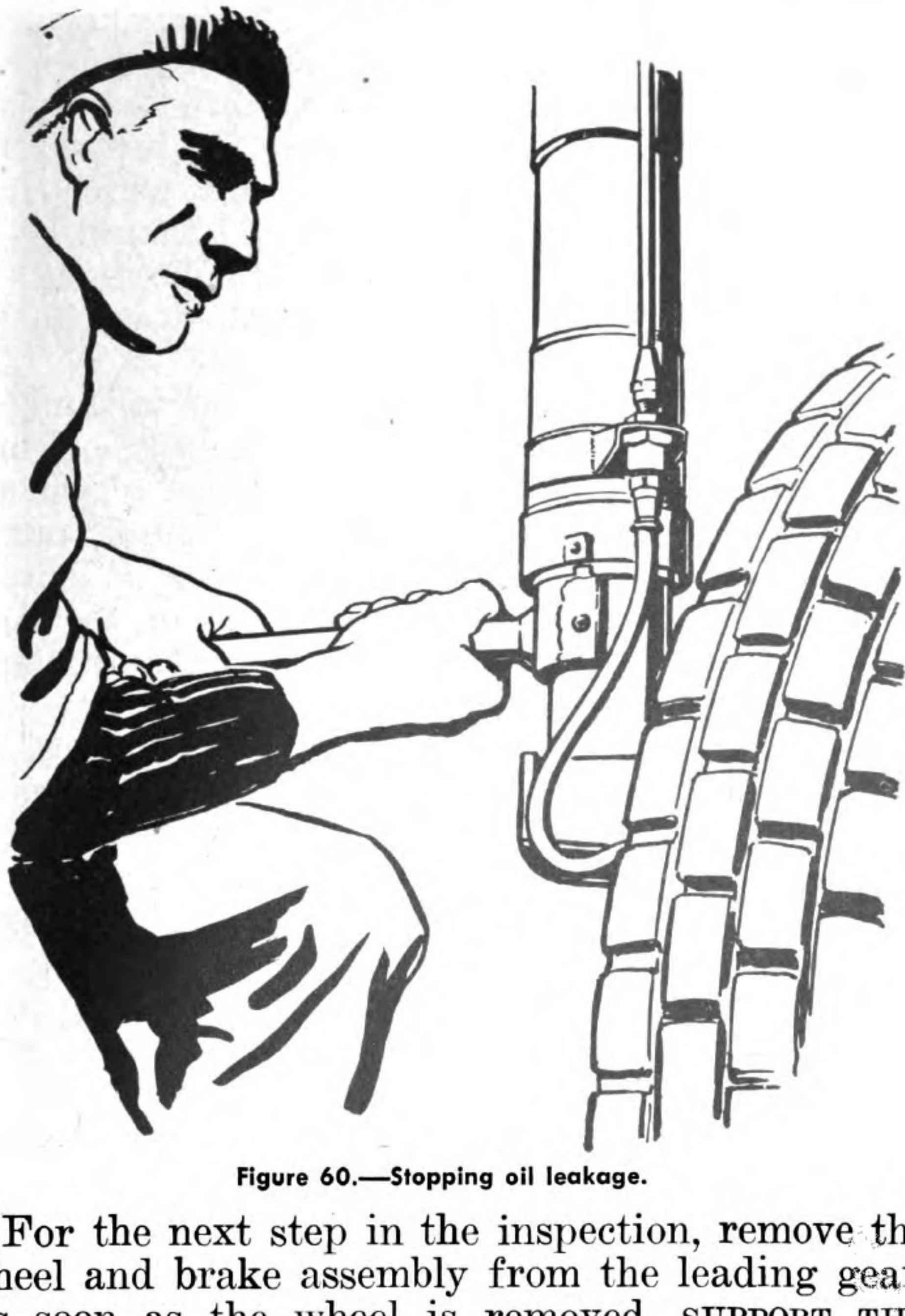


Figure 60.—Stopping oil leakage.

For the next step in the inspection, remove the wheel and brake assembly from the leading gear. As soon as the wheel is removed, SUPPORT THE AXLE ON A WOODEN BLOCK. This may prevent a serious accident in case the jack slips. Then

remove the brake assembly from the wheel as shown in figure 61. Clean and wash the bearings. Then lubricate with a nonfluid grease. Don't put too much grease on the bearings. Excess grease is likely to get on the brake drum which would make the brakes ineffective, or make them "grab." Inspect the brake drum surfaces for roughness or cracks. If any bolts are found to be loose, replace them. Next, inspect the brake shoes and linings. Linings—or moldings which have become oil-soaked—will "grab" and should be replaced. Replace any molding which shows excessive cracking, or which is worn down to the rivets.

Check the tires for cuts, weak spots, and excessive wear. A blow-out during a take-off or a landing might cause a bad accident! Test the tire valves for leaks. If a leak is found, put in new valves or new tubes IMMEDIATELY. When the wheel-and-brake assembly is put back on the landing gear, check the locking lugs and axle clamp bolts for wear.

If it isn't necessary to adjust the brakes, inspect the wheel cylinders and lines for signs of leaks. If the airplane is equipped with MECHANICAL brakes, the hook-up with the pedals should be carefully checked over. Test the tie rods for looseness. Adjust the bell crank. Replace all worn or frayed cable. Also test the hook-up to be sure that the brakes release rapidly and with SNAP to the FULL OFF position.

The tail wheel of most trainers is mounted to swivel through 360°. This part of the landing gear should be checked regularly for mechanical defects. Be sure the wheel swivel is free to turn completely around, and that the wheel turns easily on the axle. Many tail wheels are equipped with a locking device which prevents swiveling. Oper-

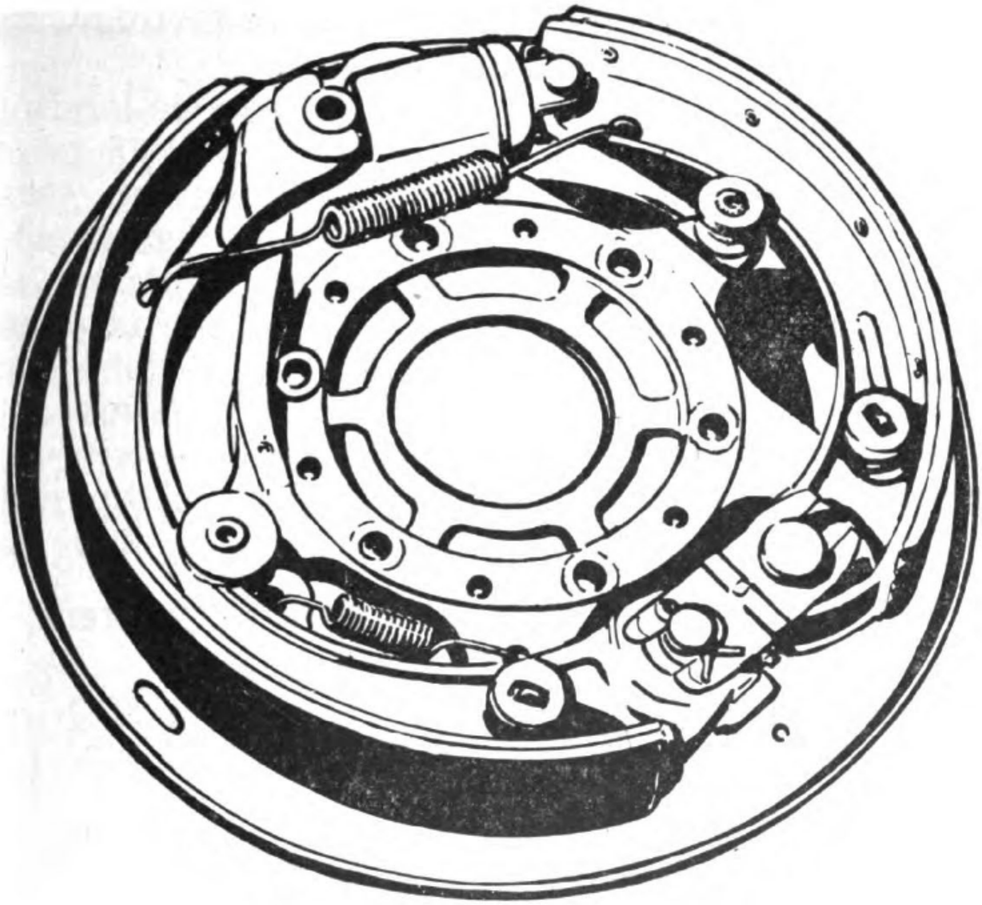


Figure 61.—Brake assembly removed.

ate the mechanism and check the wheel to be sure it locks in position and is in good working order.

Now consider retractable landing mechanisms. As you already know, this type of gear is used on land planes to raise the wheels into the fuselage or wings in order to reduce the air resistance or drag. It is also used on amphibians to permit the wheels to be raised when making a landing or take-off on water. Many airplanes used by the Navy have this kind of landing gear.

Retractable landing-gear mechanisms are not all the same, of course. But you can get the general idea of inspection and maintenance pro-

cedure for retractable gear from the following explanations.

Many of the service jobs on retractable landing gear are similar to those for fixed landing gear. But in retractable landing gear there are ADDITIONAL points of service which require regular and careful inspection. First, get a quick picture of how a typical landing gear of this type is operated. The under-carriage is hinged to the lower structure of the wing or fuselage. Thus the wheel can be swung up into either the wing or fuselage while the airplane is in flight. A hydraulic cylinder and piston arrangement called the

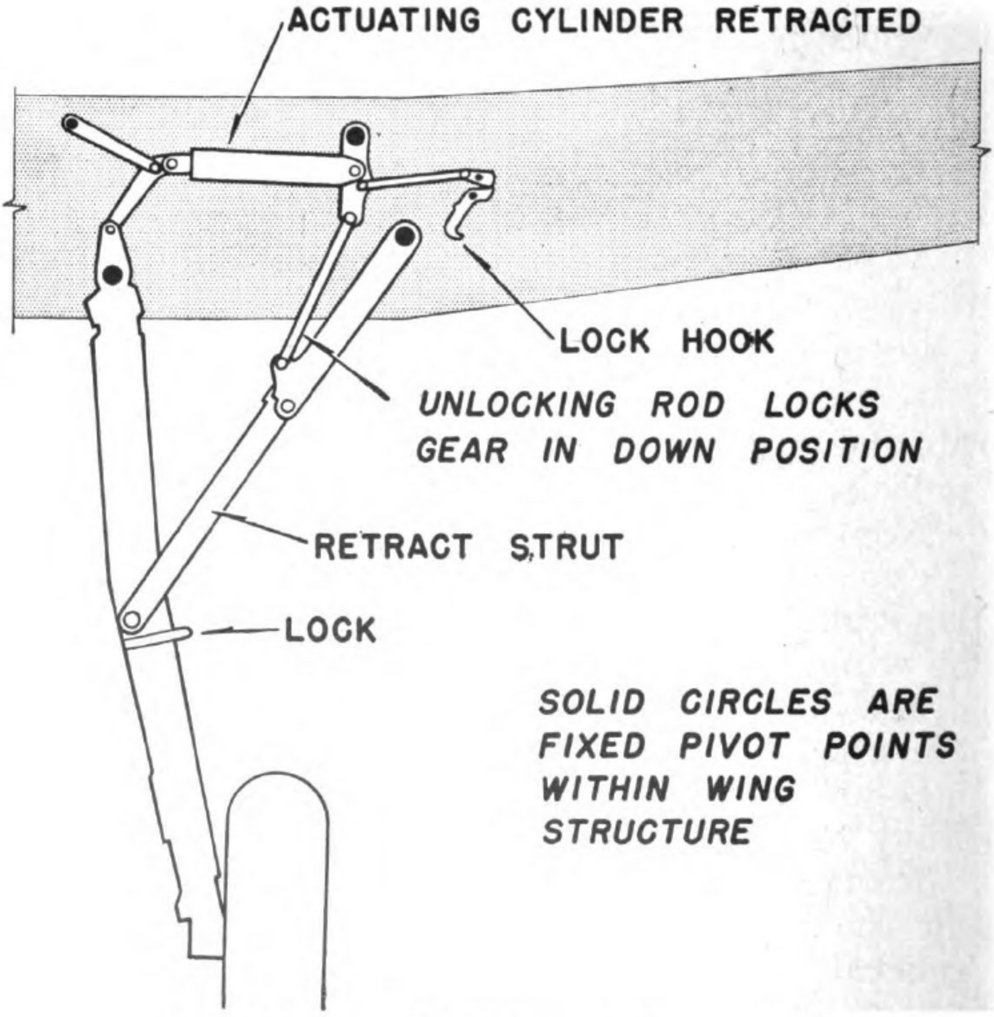


Figure 62.—Retractable landing gear (down position).

RETRACT STRUT pulls the wheel up or pushes it down. The landing shock is taken by oleo struts like those you have already studied. The wheels are equipped with hydraulic brakes which are powered from the airplane's hydraulic system.

Naturally, such a system must be frequently checked if it is to be kept in perfect working order. Careful and regular inspections are the ONLY guarantees of safety! Be sure the safety pin (or whatever device is used to prevent the gear from accidental collapse) is in place before you do any work. Also before checking the landing gear, jack up the airplane. Be sure the jack is on the jack pad provided for this purpose.

You can make a good check of the retractable landing gear on any ship if you bear in mind the job the landing gear must do. The landing gear and wheels—

MUST STAY ON.
WHEN DOWN, MUST STAY DOWN.
MUST GO DOWN WHEN NEEDED.
MUST GO UP WHEN NOT NEEDED.
WHEN UP, MUST STAY UP.

STRUTS AND HINGES

The landing gear must stay on or else the pilot and crew are in for a tough time upon landing. So START CHECKING THE STRUTS AND HINGES THAT HOLD THE GEAR ON. First off, examine the metal struts. If the metal tubing struts are cracked or buckled, you must replace the gear. The next point of inspection is the BUSHING, where the undercarriage is hinged to the airplane. These bushings must be properly lubricated. You should inspect them for wear and should replace worn or loose bushings. The bolts holding the frame of the landing gear to the fuselage should be tested

for looseness by pushing and pulling the struts to find any play that may be in the joints. The nuts should be checked for wear.

If the gear folds up on a landing, it's about as bad as if it weren't there, so CHECK THE LOCKING DEVICE NEXT. The mechanical latch is a safety device which helps to hold the wheels in the "down" position as you see in figure 63. The latch control is connected to the landing-gear control in such a way that the latch must be raised before the landing-gear control can be moved to the "up" position to retract the wheels. You

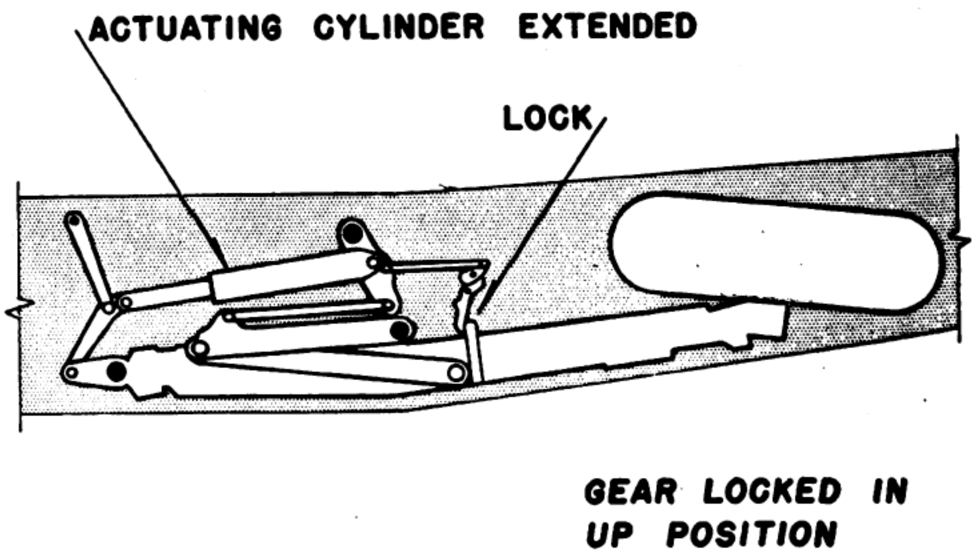


Figure 63.—Mechanical lock.

should make tests to be sure that the mechanical latch control synchronizes with the landing-gear control. You should also clean and relubricate the latch mechanism frequently.

Those wheels must go down when the pilot wants them to—or else he's in for a crash. Also, they must come up and stay up if they are to be of any advantage. In other words, the retract strut must be working right. It's one of the most important devices in the whole retractable

landing-gear system. This is the mechanism which extends and retracts the wheels. You should regularly inspect the retract strut and test it as follows.

With the landing gear control at neutral, the pressure in the strut should hold the wheels in the fully retracted position for at least five minutes. Examine the retract strut hoses for leaks and deterioration. While checking the retraction of the gear, be sure it has proper clearance at all points. With the gear in the fully extended position, check the hook on the retract strut. See that the hook is properly adjusted, and that it extends far enough back into the mechanical latch so that it will engage properly when the gear is in the fully retracted position.

Figure 64.—Removing axle.

The next point of inspection is the oleo shock absorber strut, but you've already studied this device in connection with fixed landing gears. So move along to the inspection of the airplane's brake mechanism. It is a part of the general inspection of the whole wheel assembly. The hydraulic brakes are linked to the same hydraulic system which operates the retract strut. The whole landing-gear mechanism depends on the proper working of the hydraulic system. Thus, you should make complete check of the hydraulic system whenever the landing gear is given a major inspection.

The first step in the inspection of the wheel assembly is the removal of the wheel from the landing gear. Then remove the tire from the wheel and remove the axle as shown in figure 64. Lift out the bearings. Wash the wheels, brake assemblies, axles, and spacers with cleaning solvent, but DON'T get solvent on brake linings. Remove talcum from the wheel flanges with a wire brush. Inspect the bearings and coat the collars and outer bearing races with nonfluid grease. Inspect the soundness of the brake drums. Inspect the drum surface for roughness or cracks. Brake-drum bolts should be replaced, if loose. Inspect the wheel and bearing-cut assembly for cracks, worn or damaged castings, worn locking lugs, elongated drums and attaching holes, and dents in the rim flanges. Check tire, tube, valve stem, and valve. Inspect the brake-shoe assemblies and remove any oil-soaked moldings. Check moldings for excessive cracking and excessive wear, brake shoes for cracks, elongated rivet holes, and distortion, and springs to see that they seat coil-to-coil when free. Inspect brake shoes for deterioration and wear. The tail gear, which is similar in construction to the front landing gear, requires the same general inspection and service.

ARRESTING HOOKS

A series of wire cables run across the deck of a carrier at spaced intervals. These compose the arresting gear. The carrier crew stand on catwalks and by means of levers raise little pieces of pipe that come out of the decks. These pipes elevate the arresting wires about 6 to 9 inches to catch the hooks on the landing airplane.

As the airplane settles to the deck, wheels and hooks are down. The pilot controls the raising or lowering of the hook by means of a lever from the cockpit. The hook catches in the arresting gear and brings the airplane to a sudden stop. Hook men then race out and disengage the hook.

These hooks are equipped with self-contained hydraulic arresting shock absorbers. The hooks themselves are chromium plated in order to avoid excessive wear from the cross deck arresting wires.

If inspection discloses that an arresting hook is worn or has developed cracks to such an extent that welding repair is necessary, then replace it with a new hook. In fact, a Navy Technical Order requires that all hooks, which have worn through the chromium plate over an area one-half of an inch long, shall be shipped to the Naval Aircraft Factory or Naval Air Station at San Diego, Calif., for replating.

You'll find, however, that many cracks which appear on arresting hook heads do not affect the operating strength of the hook. Small cracks, which may appear in the hook throat at right angles to the cable markings, are due to flexing of the hook throat during the arresting process. Actually, these small cracks are in a low stressed region and do not seriously affect the strength of the hook provided they don't become too extensive. In general, cracks located in the shank,

the shank-head weld connection, and in the stressed portions of the head DO affect the strength of the hook. In such cases, replace the hook. And, if you have any doubts, reject the hook until it has been tested with a proof load.

TIRE CHANGING AND REPAIR

You can change the tires on small airplanes in the field by hand. But wherever possible, you should use a tire removing tool or stand bolted to the floor or anchored to the ground.

In changing small tires by hand, you should first deflate the tube completely. Break the bead of the casing loose from the flange of the wheel. You can use tire irons the way you used to when you changed a tire on your own jalopy. Force the tire to the center of the wheel by using two irons. Remove the snap ring from the wheel flange. Remove the outer flange from the tire, lift the wheel out of the tire and remove the tube from the casing.

When you're ready for installation, make sure first that the tube is completely deflated. Then insert it in the tire.

Inflate the tube enough to remove all wrinkles. Place the wheel in the casing. The valve stem must be guided into the well and valve hole in the wheel so as to avoid damage to the tube and to the valve stem. Install the wheel flange. The wheel flange and the wheel must be balanced according to markings on both. Install the snap ring. Inflate the tire slowly. Tap the casing at different points with the flat side of a tire tool so that all wrinkles in the tube will be completely smoothed out.

If the tire is a large one, you should deflate it first, just as for a smaller tire. Then put the

wheel on a tire removing stand. Place a steel ring on the top side of the tire at the bead. Apply a spider. This will tighten down the steel ring until the tire is broken loose from the wheel and forced to the center of the rim. You can then remove the tire with tire tools. Nose and tail wheel tires, which are equipped with dual-seal inner tubes can be removed in the same way. This method of tire removal is recommended for tires mounted on one-piece wheels, particularly for 44- and 47-inch tires.

You can remove tires on demountable wheels, however, without the use of the tire removing stand. This type of wheel is held together with bolts and nuts. When you remove the bolts, the wheel separates in the middle and is taken out of the bead of the tire. Be sure, though, that the tires are completely deflated before you remove the wheel bolts.

After the tire casing is mounted on the wheel, you should paint a red oblong marking, about one-half inch wide by 1 inch long, on it. And also paint a similar one on the rim of the wheel. Thus, you can easily detect slipping of the tire on landing and take-off. You should make an inspection after each flight to see that these markings coincide. If you don't the tire might slip to such an extent that the valve would be ripped from the tube.

At each regular inspection of an airplane, you should carefully check the tires and rims. If you find the tread of the tire worn and the fabric carcass of the casing exposed, you should replace the tire. Look carefully for external breaks, cuts, blisters, loose cords, or other damage, and repair the casing if practical.

Examine the visible portion of the wheel rim for signs of excessive corrosion. Clean the rim if corroded and renew the protecting coating of paint if it's worn through. If you find evidence of damage to wheel rim edges as a result of hard landings, remove the casing and examine tire, tube, and rim for damage. Moreover, if you suspect the tires have struck large stones or other damaging objects remove them and carefully inspect not only the tires, but also the tubes and the rims.

In checking a tube, examine the valve for physical damage or faulty attachment to the tube. Look for thin spots, cuts, punctures, chafing, wrinkles, creases or other damage.

REPAIRING TIRE PUNCTURES

You should make repairs only on tubes damaged by punctures, cuts, or by casing breaks provided the damaged area is not larger than one inch in its longest dimension. Send all tubes with larger damaged areas to repair bases.

If the damage is such that you are going to repair it, roughen the surface of the tube around the failure with a buffer or knife. Apply cement to the roughened surface and spread it evenly. Scrape off excess cement.

When the cement becomes tacky (sticky) take a prepared patch, remove the protecting cloth and apply the patch. Be careful not to touch the sticky surface of the patch with your fingers. All patches, whether prepared or cut, must be large enough to allow at least one-half inch between the puncture and the edge of the patch in all directions.

After the patch has been applied, roll out, with a can or suitable roller, any air pockets under the surface of the patch. Thin spots and cuts may be

repaired by patching or vulcanizing. You should limit the patch size and the number of patches, as the weight might otherwise cause tube unbalancing. If large holes, or thin or chafed areas are present, the tube must be returned to a base for repair.

TIRE REPAIR

If a tire has tread cuts which do not penetrate the fabric, you should clean them, fill them with commercial tire cut filler, and cement them in place. If there are side wall blisters that can be cleaned and repaired with no damage to the fabric carcass, clean them with wash thinner or gasoline. Buff the area and cement with aircraft rubber cement. You can use the same procedure if the rubber fairing immediately above the rim flange separates from the fabric carcass with no injury apparent to the carcass. Be sure you allow the cement to become tacky. Then press the rubber side wall firmly against the fabric carcass. You should also use some means of maintaining a constant pressure on the repaired area until the cement is thoroughly dry.

ASSEMBLING TIRE AND TUBE ON WHEEL

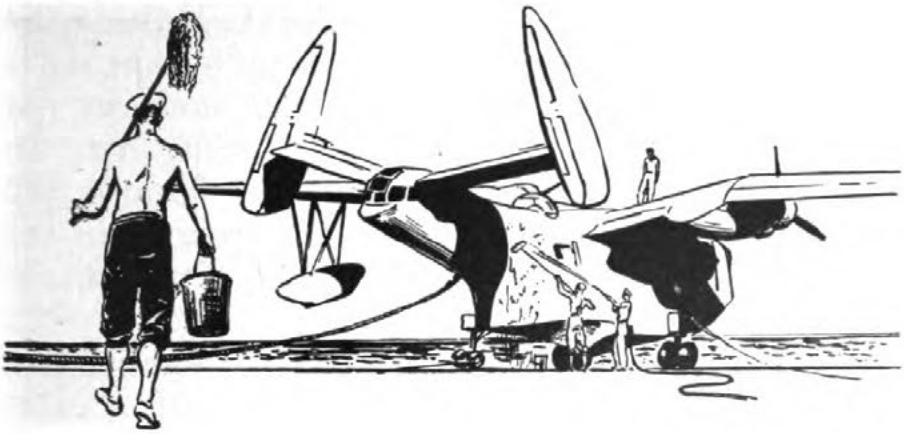
Lay the wheel on a flat, smooth surface with the drop center rim portion toward the top. Mount one bead of the casing on the rim by means of standard tire tools. Tie a 2-foot cord securely onto the valve stem or screw on a valve extension. Insert the tube into the casing but be sure the heavy part of the tube is 180° from the heavy portion of the tire and that the valve stem coincides with the valve hole.

Thread the valve stem string or extension through the valve stem hole in the rim. Screw on the valve lock nut a few turns if one is used.

Then add enough air to shape the tube. If you add too much air, you'll have difficulty mounting the remaining bead of the casing.

Now mount this casing, but start opposite the valve. After the casing is properly mounted, add air slowly until the casing beads set. If they don't set properly, deflate the tube, realine the casing, and then reinflate. Don't use soap or powdered tire talc as aids in seating the bead. Remove the valve core and fully deflate the tube to relieve the pressure on any folds or buckles and to permit the tube to assume its proper contour within the casing. Be sure both casing beads remain properly seated on the rim.

Finally, replace the valve core, inflate the tire to the required pressure, and tighten the valve lock nut if one is used. Inflation pressures vary, of course, with loading conditions.



CHAPTER 13

CORROSION

BEATING THE MENACE

Iron or steel rusts when left in the open or exposed to moisture. Rust is another name for iron oxide. It is formed when the oxygen in the air or water unites with iron. This rust-forming process is called CORROSION—one of nature's most deadly cutting tools and an enemy of airplanes.

You'll find—to your sorrow—that all metals corrode. The corrosion of most metals is caused by oxygen uniting with the metal. But certain conditions speed up the process. For instance, it is faster when there is a lot of moisture in the air and, of course, airplanes flying through wet clouds are continually exposed to moisture.

Metals also corrode quickly in water that has air in it. And the water in oceans, lakes and rivers contains large quantities of air.

So it's a COMBINATION OF AIR AND WATER that speeds ordinary corrosion. Remember also, that the metal doesn't have to be dripping with water. In fact, you'll find that a very thin film of moisture—such as is caused by high humidity in the

air—is sufficient to cause corrosion. Moreover, salt, dirt, dust, acid, alkali, and certain other chemicals also cause corrosion. Since ocean water and the ATMOSPHERE OVER THE OCEAN contain considerable salt, the combination of salt, air and water hastens corrosion even more. That's why anticorrosion measures are so important in the care of Navy airplanes which must fly regularly under such conditions.

There are two other types of corrosion taking place on aircraft. The first is called "intergranular" corrosion and takes place between the different metals in alloys. Usually, it's the result of faulty heat treatment. Crystals of the metals (such as copper or aluminum) form. In the presence of sea water especially, either chemical or electrical action may take place between the crystals so that one or both are eaten away. You can see that this reduces the strength of the metal. If that metal is only 25 thousandths of an inch thick to begin with (as in a metal skin), it may be serious. The ONLY remedy is the REPLACEMENT of the part.

The other type of corrosion results from ELECTROLYTIC action between two touching surfaces that are made of different metals. The two metals, and the moisture (especially salt water) act just like a small electric battery. An electric current is set up which causes either one or both metals to disintegrate rapidly.

To guard against electrolytic action, the metal parts have to be separated by some substance that will not act in such a manner. A common practice is to use strips of cloth soaked in asphalt paint. Another method is to paint both meeting surfaces with barium chromate. Where copper or copper alloys (such as bronze) are to be in contact with aluminum, the copper should be

cadmium plated, whether it is separated by insulating material or not.

The protection of inside surfaces, which cannot be inspected readily, is also particularly important. You can protect bare metal against ordinary rust by a thin film of oil which you spray into enclosed spaces. Tubular structures are protected with either LINSEED oil or an approved equivalent.

PREVENTING ORDINARY CORROSION

You can't change the properties of metals, but you CAN TAKE definite steps to reduce the dangers of ordinary corrosion. You can coat a metal with some chemical or mixture of chemicals to keep air and water from its surface. You can use paint, lacquer, shellac, wax, oil, or other similar materials.

It's also possible to take a metal that corrodes quickly, and coat it with one that corrodes slowly. Nickel plating, copper plating, and cadmium and chromium plating are examples of protection against corrosion.

You won't be doing these plating jobs. They're done mostly at factories, but other anticorrosion measures, which you can perform at your base will be your responsibilities.

REMOVAL OF OLD PROTECTIVE COATINGS

Before you attempt any repairs, you should inspect the damaged areas. You can recognize the extent of damage and corrosion by the dulling or pitting of the surface. This dulling or pitting is accompanied by whitish or reddish powdery deposits.

You can test for ordinary corrosion by probing for pits with a fine needle—like a dentist looking for tooth cavities. You and your chief will have

to decide whether such corrosion, when found, can be repaired or whether the metal should be cut out and a replacement piece installed.

After your inspection, remove all protective coatings, such as grease, paints, primers, and plating in the immediate area to be repaired. Chemical methods of removal are preferred to any mechanical method such as sandpapering, wire brushing, sandblasting, and scraping. If you can immerse the parts in a tank for removing the paint, use an alkaline cleaner or stripper, such as Navy Aeronautical Specification No. C–67.

Be sure you DON'T leave aluminum or magnesium parts in the cleaning solution too long since these chemicals will actually dissolve the parts. If you don't have facilities for complete immersion in a recommended paint stripper, you can use a surface solvent. You spread it on, allow it to stand for a few minutes, and then wipe off the paint as it softens and lifts. You should rinse off the parts with thinner, mineral spirits, or water (whichever is recommended) afterward.

Here's a point to mark down in your mental notebook of safety rules. YOU MUST PROVIDE ADEQUATE VENTILATION AND AVOID EXPOSED FLAMES AND SPARKS in the vicinity of inflammable paint removers.

After the paint or protective coating has been removed, inspect the part to determine to what extent the base metal has been damaged. Remove all products of corrosion—such as scale, loose metal flakes, powder, and salt crystals. You may find it necessary at times to use sandpaper, wire brushing, or other abrasives. But once again, CHEMICAL TREATMENTS ARE BEST. When you've finished this cleaning job, the surface should be bright and clean—at least so far as you can see with your naked eye.

With the mechanical clean-up job out of the way, you should swab the entire area—except in the case of magnesium—with a solution of sodium or potassium chromate or dichromate. This makes the surface inactive and penetrates into any crevices or pits that have not been mechanically removed.

You can carry these chromate salts dry and mix them with water on the job. That's a big help during operations in combat zones.

ANODIZING

There is a more complicated process of protecting aluminum and aluminum alloy parts. It's called ANODIZING. It consists of forming a film of aluminum oxide on the surface of the part by electro-chemical means. This film serves as a protection against corrosion. Certain specified aluminum alloys, however, DON'T REQUIRE ANODIZING for interior parts and surfaces. These include No. 2S aluminum and the following alloys—Nos. 3S, 52S, 53S, 61S, 17S Alclad, and 24S Alclad. Moreover, many electrical parts are not anodized because of the high electrical resistance of the aluminum oxide film.

The next preferred surface treatment prior to painting is the ALROK PROCESS, patented by the Aluminum Company of America. But you don't need to worry about either anodizing or the Alrok process. If either of these processes is used at your base, you'll get special instructions on the method. However, you can use an alternative treatment for wrought or cast alloys, which you want protected.

Here's the way to do it. Use a 5 percent sodium carbonate, 1½ percent potassium chromate solution. Simmer till gently boiling and immerse parts for 20 minutes. Then give the

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parts a sealing treatment of 15 minutes in a solution containing 8 ounces per gallon of sodium ortho-silicate, gently boiling also.

If that procedure is impractical, you can use the chromic acid dip treatment on aluminum, aluminum alloy, or steel. It consists of the application of a chromic acid solution to the part to be treated, or by brushing the solution on the surfaces. You should leave the solution on the surface from 5 to 10 minutes. Then wash with cold or hot water. You can also use an alcoholic-phosphoric wash in a similar manner, but you should permit it to remain on the surface FROM 1 TO 2 MINUTES ONLY before washing with hot water. Moreover, NO PARTS TREATED BY THE PHOSPHORIC-ACID METHOD MAY BE LEFT UNPAINTED.

APPLICATION OF PROTECTIVE COATINGS

In general, steel, brass, bronze and copper parts are cadmium-plated, but, as has been mentioned, you don't need to be concerned here with the electroplating of metals. One of your immediate jobs, however, will be to apply paint-type coatings to various surfaces after you've inspected them and given them a surface pre-treatment.

If you have a choice of removing the anodic coating or leaving patches of it, LEAVE THE PATCHES. Anodic film—though not intact—is preferable to no anodic film at all. You should also retain patches of Alclad coating wherever possible.

When there is no contamination of the surface—between the surface pretreatment and painting—you don't need to do any further cleaning. If there's a delay in handling parts between processes, you should reclean the material.

There are various cleaners you might use—such as carbon tetrachloride, trichloroethylene, or

a phosphoric acid cleaner, called Deoxidine. These will remove any dirt, grease and oil which might have collected on the parts. DON'T inhale the vapors, however, if chlorinated solvents are used. They are very poisonous.

Remember CLEANING is one of the most important steps in any finishing job. Don't ever make the mistake of applying finishes over surfaces that are not absolutely clean.

Before you begin to apply the primer (first coat) make sure the surface is dry. If possible, you should apply paint coatings in well-ventilated, warm air-conditioned rooms of low humidity. But you'll have to do the best you can under whatever conditions you work in wartime. One warning, though—if you are inside, be careful NOT TO INHALE PAINT VAPORS for extended periods. They're not healthy!

If the part you're going to paint is still attached to the airplane, you should carefully mask all nearby surfaces that are not to be refinished, but don't leave any cans of paint or working materials standing on the wings—even if they are protected.

The primer, or first coat, should have an oil base. If the metal surfaces are to be enameled or lacquered, thin the primer with toluene thinner. Use two or three parts of toluene to one part of primer. Then you're ready to apply the priming coat by dipping, brushing, or spraying.

Usually, dipping is practical only in factories or large repair stations. As the name implies, dipping consists of putting the metal part into a large container filled with the primer. It is then hung up to dry. You can also apply the priming coat with a brush—if you're careful to cover the surface evenly and thinly. A thin coat of primer gives the best results.

The SPRAY GUN, however, is the most satisfactory method of applying the primer. It's quicker, easier and gives the best results.

Hold the spray gun close to the surface to prevent drying and dusting of the primer before it reaches the metal. The primer dries quickly, but you should let it dry from 12 to 24 hours anyhow.

No matter how careful you are, you're liable to miss a spot now and then. Here's a trick that will help you find the missed places. If you use zinc chromate primer (first coat) tint the second coat a little and you'll be able to detect the "holidays" (places you missed).

On parts such as struts or sheet metal, you may apply as many as five to seven coats of lacquer, or two coats of enamel. Allow from 30 to 45 minutes for drying between coats of lacquer. Allow 12 hours between each coat of enamel.

For the final finish, too, you should "thin" lacquer of the desired color from 10 percent to 35 percent with a thinner. You can learn a few tricks on this point from a chief whose experience has taught him the best way to thin the lacquer. If you use aircraft enamel, thin it with turpentine.

IN THE TIGHT SPOTS

At bases and stations you'll have equipment and materials available so that you can take anticorrosion precautions such as those just outlined.

Suppose, however, that you're on a small Pacific atoll. Jap Zeros are buzzing around in the area. Your airplanes have been doing double duty in all kinds of weather. Your available equipment, materials, and maintenance are limited.

What anticorrosion measures are you going to take?

You've got to face the facts of this situation. And that means you must do the best possible job in the time you have with the available materials and equipment. There is a procedure for LIMITED anticorrosion measures. But, REMEMBER, you're to use this technique only in cases where the proper materials or equipment are not available, or where time will not permit extensive repair measures.

First off, examine the part in question for corrosion. If it's damaged beyond repair, replace it with another part. If patching is indicated, scrape off or otherwise remove the loose paint and the powdery products of corrosion.

Wash off the areas with soap and water or with lacquer thinner or other solvent. Dry the surface and paint with two coats of zinc chromate primer. If top coat paint is available, cover with paint which will match adjacent surfaces in color. If PARALKETONE (AN–C–52 Type I) is available, apply it liberally over the paint. Paralketone is a greaselike material, made from oxidized hydrocarbons, and is intended for use as an all-purpose rust preventive. If you don't have paralketone, however, use some other greaselike material.

If paint cannot be obtained, use grease over the bare metal. If the part has corroded too far to withstand normal loads before the airplane can reach a major overhaul base, metal patching will necessarily have to be performed on the part before the aircraft is in condition for flight.

Don't ever underrate the importance of anticorrosion precautions. Airplane struts, tie rods, landing gear, sheet metal surfaces and many other parts are designed to carry vital loads. Anything affecting their safety, affects the safety of the whole ship. So keep SAFETY in mind as you take steps to defeat the corrosion menace.

CHAPTER 14

PRELUDE TO FLIGHT

THE FINAL CHECK-UP

All the tasks that you perform in connection with Navy airplanes are important, but probably none is more so than your line inspection. That's the final check-up before the airplane takes off. You've got to be thorough in that inspection. Slipping up on something JUST ONCE is too often.

YOUR OK MEANS THAT AIRPLANE IS READY TO FLY.

LINE SERVICE

You make your line inspection shortly before the airplane is ready to take off. Before that, however, comes line servicing which consists of refueling, checking the oil, checking the tires, and adding air or oil to the oleo system. Perhaps your engine man will perform some of these duties, but you ought to know the complete procedure.

Here are some "musts" BEFORE refueling any airplane—

First, put the airplane in a safe place and away from any fire hazard. Carefully chock the wheels. Move the fuel truck into position for refueling. DRIVE CAREFULLY. Put a portable fire extinguisher within 50 feet of the airplane. Be sure no one smokes near the airplane.

Ground the refueling hose. Attach one end of a refueling truck ground wire to the landing gear. You'll find filler necks located in different places on the various types of Navy airplanes. On the Navy's torpedo bomber, TBF–1, for instance, the center main-tank filler neck is behind a hinged door on the left-hand side of the fuselage above the wing. To open the door, you loosen the turn fastener. The left and right main tank filler caps on the TBF–1 are on top of the wings, next to the walkways. The droppable tank on this airplane filler neck can be reached through a hinged cover plate on the top of the right main tank filler neck. You can also open this by loosening the turn fastener.

DON'T DRAG the fuel hose over the airplane wing or any other part of the airplane. And be careful not to overflow the fuel tanks because overflow endangers the airplane and YOU TOO. Aviation gasoline spilled on your skin can cause serious burns. Be particularly careful to keep it off your face and out of your eyes.

Don't rely on fuel gages alone. Measure the amount of gas with a measuring stick. Of course, you can't use this method of measuring with a droppable tank. After you've check the amount, make sure the fuel tank caps are on tight. Remove all ground wires and any other equipment used in the refueling process.

In CHECKING OIL, you'll need to know the capacity of the oil tank of the particular airplane. On the TBF the tank's capacity is—normal, 11 gallons, overload, 17 gallons, and maximum, 32 gallons.

To check the amount of oil, unscrew the sounding rod. Pull it out. The amount of oil in the tank is shown on the sounding rod markings.

Add only enough oil to bring it up to capacity level. NEVER OVERFILL THE OIL TANK. After the oil is up to capacity, put on the cap and make sure it is on tight. Wipe up any spilled oil.

Tire valves on many airplanes are in the open. In that case you don't have to remove any plates to get at them. CHECK THE TIRES for the proper pressure. Always be sure to replace tire valve caps afterward. Check the tail wheel likewise unless it's solid rubber, as it is in many airplanes.

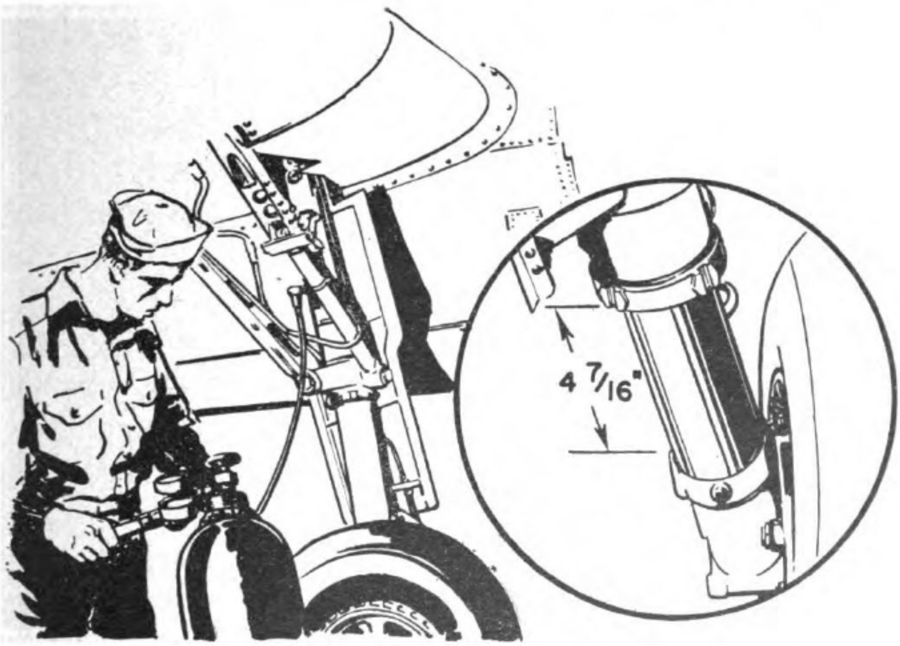

Figure 65.—Making oleo adjustment.

To keep the correct adjustment of the OLEO SYSTEM, you'll often have to add or remove air. On the TBF-1, which we're using as an example, the proper adjustment is $4\frac{7}{16}$ inches. Oleo systems are usually serviced through a valve on the upper part of the shock strut.

If you want to shorten the oleo adjustment, remove air from the system by loosening the valve seat nut slightly as shown in figure 65. As you do it count slowly to 10. On the final count

tighten the nut again. Then move the airplane and drop a chock in the path of a wheel while it is moving. That will bring the airplane to an abrupt halt and will jar the oleo system enough to shorten the adjustment for as much air as has been removed.

Next check the adjustment to see if it is correct. Do this as many times as is necessary to reduce the adjustment to the correct length.

Suppose you want to lengthen the oleo adjustment. Here's how—First, remove the valve cap. Then attach the hose connection of a high-pressure air bottle to the oleo air valve. Add the air slowly. Check the adjustment measurement often, so that you won't put too much air in the system. Check the air valve by moistening it. Bubbles indicate a stuck or leaking valve, which should be replaced.

The rear wheel oleo system is serviced in the same way. The air valve will probably be in a different place, however. For instance, on the TBF-1 it is inside the rear fuselage, just above the rear wheel assembly. The rear wheel adjustment is not as exacting as that for the landing gear. The rear wheel pivot on the TBF-1 should be straight up and down when it has been properly adjusted.

LINE INSPECTION

As a line inspector you have three jobs to do—

To look for any visible worn parts.

To make sure that the controls operate smoothly and properly.

To see that everything is secure and that all connections are safetied.

Before inspecting any airplane, MAKE CERTAIN THE IGNITION SWITCH IS OFF.

Inspect the blades of the propeller for sharp dents, pits, cracks, and nicks—especially along the leading edges. Check the propeller hub assembly and slinger ring for any signs of cracks. Be sure all lugs are safetied.

Inspect the wheels for cracks or for bent rims. Check the tires for cuts, gashes, or any other signs of defects. See that the tires have the right air pressure. Check the wheel hub caps for security and be sure the lock ring is in place.

Go over all the LANDING GEAR STRUTS. Look for any signs of cracks and bends, and for broken or defective attachment fittings.

Be sure the WING IS LOCKED IN SPREAD POSITION. If it's the TBF-1, you can check this by the position of the wing-lock indicator flag on the top side of the wing at the fold. Inspect the aileron hinges and pins for security of attachments and lubrication. Check the aileron horns for bends. See that all attachments of control cables are secure.

Next check the operation of the control system from the cockpit. Move the stick in all directions and check the motion of all control surfaces. Try the stick for free and full movement, and any lost motion. Remove the boot (that's the covering around the stick) by pulling the snap fasteners. See that all control connections are safetied. Then replace the boot right away. Check the rudder pedal control system for full throw and smooth operation by moving the pedals to extreme positions.

Inspect all control cables, guides, and sheaves for frayed cables, proper tension, bent rods, loose fittings, loose turnbuckles, defective safety wires, and loose nuts and bolts. This inspection of the

control cables is made in different places, depending on the type of airplane. On the TBF–1, for instance, you can do it from the bombardier's compartment.

Inspect all of the engine mount hold-down bolts for security.

The TAIL is next on the list. Inspect the tail surfaces for the condition of the ribs and other structural parts—including bolts, nuts, and cotter-pins. You can usually feel any parts that are broken. Check the tail control surface horns for accidental bends—and for security of attachments to control surfaces and control cables. Inspect all control surface hinges, hinge pins and bolts for security, safetying, and lubrication.

Inspect the tail wheel assembly for cracks, breaks, or signs of wear. Look, too, for shock absorbers that are weak or don't work right. Examine the fuselage around the tail wheel assembly to see that no damage has been done by the tail wheel assembly. That completes the line inspection for the structural units of the airplane. The rest of the preflight inspection has to do with the engine. Your powerplant specialist will probably take care of that. But even so you should know the principal steps in the preflight engine check-up.

That completes your line inspection, but ask yourself a couple of questions before you put your O. K. on the airplane.

HAVE YOU BEEN THOROUGH?

CAN THE PILOT COUNT ON THE AIRPLANE BEING RIGHT?

Your answers had better be YES because here comes the pilot now. And that airplane you've put in shape has a date with the enemy.